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ENVIRONMENTAL IMPACTS, EFFICIENCY, AND COST OF ENERGY SUPPLY AND END USE. VOLUME 1

HITTMAN ASSOCIATES, INCORPORATED

PREPARED FOR
NATIONAL SCIENCE FOUNDATION
ENVIRONMENTAL PROTECTION AGENCY
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ENVIRONMENTAL IMPACTS, EFFICIENCY, AND COST OF ENERGY SUPPLY AND END USE

VOLUME I FINAL REPORT

HIT-592

November 1974

Work Sponsored by

The Council on Environmental Quality,
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Contract EQC 308

HITTMAN ASSOCIATES, INC.
COLUMBIA, MARYLAND

1a

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FOREWORD

The efforts represented by this two volume final report were begun in December 1972. A draft version of Volume I was issued September 1973 and the various sections of Volume II published in draft form between February and June 1974. Extensive revisions to the draft versions of this work have resulted in a two volume final report.

Impetus for the program was recognition of a need for an organized approach to the environmental impacts caused by energy supply and use. This study, building upon earlier work completed by the Council on Environmental Quality, provides a systematic technique for identifying environmental tradeoffs and problems associated with current energy scenarios. By offering an organized and consistent approach to environmental impacts, this report can lend a quantitative sophistication to policy discussion.

This study was directed by W. Robert Menchen. Technical contributors are as follows:

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This work has been sponsored by the Council on Environmental Quality, The Environmental Protection Agency, and the RANN Program of the National Science Foundation. The Atomic Energy Commission has contributed through support of the energy modeling efforts at Brookhaven National Laboratory (BNL). The data contained in this volume are being placed in a computerized information retrieval system at BNL, and computer programs are being written which will allow rapid analysis of the environmental effects of energy systems.

Contract monitoring and all technical coordination has been through the Council on Environmental Quality. We wish to thank Dr. Steve Rattien, Dr. Stephen Gage, and Mr. Marvin Singer of that office for their continued assistance and support in this effort. Their suggestions over the course of the program have created a more useful product.

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I. INTRODUCTION AND SUMMARY

This is Volume I of a two volume report which describes the results of a study performed by Hittman Associates, Inc. (HAI), and sponsored by the Council on Environmental Quality (CEQ), The Environmental Protection Agency, and The RANN Program of the National Science Foundation. The purpose of the study was to determine the environmental impacts, efficiency, and costs associated with the supply and end use of fossil fuels. The study builds upon preliminary work already completed by CEQ.

The output of the study takes two forms. This report presents tabular, footnoted, and referenced data quantifying the broad range of energy-related environmental impacts on land, water, air, solid waste, and occupational health. All of the information contained in this report is also available in the form of a computerized data base. This data base has been given the name MERES: Matrix of Environmental Residuals for Energy Systems. As part of an ongoing contract with the Atomic Energy Commission, Brookhaven National Laboratory has created the data base, and also has written a number of data management and energy modeling programs. These programs, together with the MERES data, are known as the Energy Model and Data Base (EMDB).

Environmental analyses of energy-related facilities have previously been incomplete. Among other things, these analyses typically considered only individual components, such as an isolated power plant, refinery, etc., and not entire energy systems.

The construction of a coal-fired power plant causes air, water, solid waste, and land impacts not only at the immediate site of the power plant, but also at the site where the coal is mined, washed, processed or prepared, and along the route that the coal is transported. The entire sequence of activities, from the mining of the coal to the production of electricity, and its end use in some home appliance or industrial process, is what is referred to as an energy system or "trajectory" and should be analyzed.

Similar trajectories or energy supply "chains" exist for oil production and refining. The construction of a refinery causes air and water pollutants, solid waste, and land disruption. However, additional environmental effects are felt at the point of crude oil production, during the crude and product transportation, and at the point of marketing and end use.

Using the data bank, it is possible to aggregate the environmental impacts of a wide variety of fossil fuel "trajectories" traced from the end use of a fuel to its extraction or vice versa.

This makes it possible to estimate environmental impacts for any number of scenarios related to energy consumption patterns envisioned for the next 10 to 20 years.

The objectives of the Phase I study reported in this volume are summarized in Figure 1. Tasks 1 and 2 are national in nature while Task 3 includes the impacts of regional energy supply subsystems. In all cases, the data have been developed for coal, oil, and natural gas. A more detailed breakdown of the regions covered in Task 3 is provided by Figure 2.

Thirty environmental impact tables are contained in this report. Twelve of these are devoted to coal supply, twelve to oil supply, one to natural gas supply, four to energy end uses, and one to the electric power plant activity of energy supply. Each entry in these tables is footnoted and referenced.

The objective of the Phase II study reported in the companion Volume II, was to supplement the Phase I activities with various emerging energy technologies. Six technologies, shown in Figure 3, were characterized with respect to their environmental impacts, efficiency, and cost. These technologies represent additional links in the supply and end use chain of fossil fuels and are a necessary component of future energy investigations.

It must be noted that the environmental impacts reported herein only characterize the initial step in the environmental chain--that is, the amount of effluent discharged from the boundary surrounding a particular process or end use. The interaction of the outfall, air emission, land use, etc. with the biosphere is not included in this study.

TASK 1 EXTRACTION, PROCESSING, CONVERSION, AND DELIVERY OF FOSSIL FUEL ENERGY

OBJECTIVE 1 - DETERMINE PROCESS EFFICIENCIES FOR FOSSIL FUEL PRODUCTION AND DELIVERY

OBJECTIVE 2 - QUANTIFY ENVIRONMENTAL IMPACTS FOR EACH PROCESS, WITH PRESENT CONTROLS

OBJECTIVE 3 - DETERMINE IMPACTS WITH CONTROL TECHNOLOGY AVAILABLE AND LIKELY TO BE IMPLEMENTED

OBJECTIVE 4 - DETERMINE SYSTEM COSTS FOR UNCONTROLLED AND CONTROLLED ENERGY SUPPLY

TASK 2 END USES OF ENERGY

OBJECTIVE 1 - DETERMINE ENERGY USE PER APPROPRIATE MEASURE OF USEFUL ACTIVITY

OBJECTIVE 2 - DETERMINE ENVIRONMENTAL IMPACTS OF END USES

TASK 3 SENSITIVITY ANALYSIS OF TASK 1 DATA - REGIONAL STUDIES (BOTH UNCONTROLLED AND CONTROLLED)

Figure 1. Description of Phase I Study

COAL

- NORTHWEST (POWDER RIVER BASIN)

  MONTANA & WYOMING; AREA STRIP

- SOUTHWEST (FOUR CORNERS AREA)

  NEW MEXICO; AREA STRIP

- CENTRAL

  ILLINOIS & INDIANA; AREA STRIP; ROOM & PILLAR DEEP

- NORTHERN APPALACHIA

  NORTHERN W. VA., CENTRAL & W. PA.; CONTOUR STRIP, ROOM & PILLAR DEEP, LONGWALL DEEP

- CENTRAL APPALACHIA

  EASTERN KY., TENN., SOUTHERN W. VA.; STEEP SLOPE CONTOUR STRIP, ROOM & PILLAR DEEP

OIL

- DOMESTIC ON-SHORE
- IMPORTED SOUTH AMERICAN RESIDUAL
- IMPORTED MIDDLE EASTERN CRUDE
- IMPORTED CANADIAN CRUDE
- DOMESTIC OFF-SHORE

NATURAL GAS

- DOMESTIC ON-SHORE
- DOMESTIC OFF-SHORE
- IMPORTED CANADIAN

Figure 2. Task 3 Regional Studies

TASK 5	LOW BTU GASIFICATION OF COAL
TASK 6	HIGH BTU GASIFICATION OF COAL
TASK 7	OIL SHALE
TASK 8	FLUIDIZED BED BOILER COMBUSTION
TASK 9	SOLVENT REFINED COAL
TASK 10	COAL LIQUEFACTION

Figure 3. Phase II Study Description

II. DATA BASE DESCRIPTION

A. Nomenclature

In order to describe a scenario dealing with environmental effects of energy, a number of definitions have been adopted:*

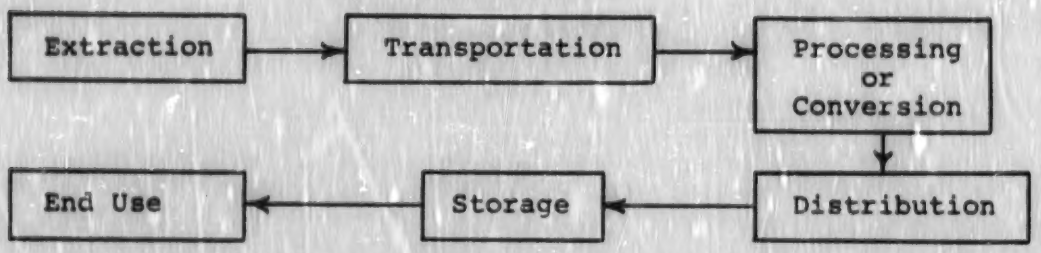
Term	Example/Definition
Element	SO_2 emission in transportation of coal by unit train
Process	Coal transportation by unit train (a set of elements)
Activity	Coal transportation (combination of a set of processes)
Trajectory	Coal in the ground to steel production by electric furnace (the set of linked activities which connect the supply of a specific resource with a specific end use)
Subsystem	Coal in the ground to any linked end use (a logical collection of trajectories defining an aspect of the total energy system)
System	Energy production and use in a given year (collection of all trajectories in the energy economy)

* These definitions are identical to those formulated by Brookhaven National Laboratory

These definitions are further explained by the following diagram:

TRAJECTORY

Sequence of Activities

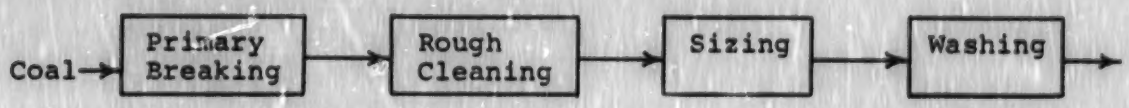


ACTIVITY

An activity is one or more processes.

One process could be distribution of coal by unit train.

Several processes in series might be as shown below.



The environmental impacts to be identified and quantified are those which relate to water pollution, air pollution, generation of solid wastes, use of land, occupational health, and potential for large scale disaster.

The water and air pollutants under consideration are the following:

Water: Acids
Bases
Dissolved solids - PO_4, NO_3, others
Suspended solids
Organics
BOD
COD
Thermal

Air: Particulates

NO_x

SO_x

Hydrocarbons

CO

Aldehydes, etc.

Solid wastes under consideration are all residuals not entering the air or water that result from the basic fuel resources or from the system processes that make fuels useful for consumption, or from the end use of fuels.

The land impacts include areas required for extraction, structures, disposal of solid wastes, roads, ports, pipelines, storage, and buffer zones. Both fixed and incremental land effects are considered. Fixed land effects are those associated with facilities such as processing plants, pipelines and storage tanks, whereas incremental land effects are those associated with excavation, such as strip mining, and solid waste disposal.

Occupational health is considered on the basis of deaths, injuries, and man-days lost due to injuries, in both the supply and end-use trajectories.

All of the environmental impacts mentioned so far are quantified and tabulated with suitable units. Further details are given in the following sections on energy supply and energy end use.

The potential for large scale disaster is identified with respect to the possible nature and magnitude of disasters and to specific processes in the supply and end-use trajectories. No quantifications are associated with these identifications.

B. Format

The construction of a computerized data bank requires that a large number of inputs be prepared according to a specific format. From the standpoint of this report, the reader need only be familiar with certain ground rules regarding data identification. The relationship between the format of data in this report and the computerized data bank is explained further in Section E.

1. Impact Data and Data Hardness

Each entry of environmental impact data in the supply and end-use tables has three parts. This is illustrated below.

2.40-04 3 7019

footnote number

data input hardness number

data input to three significant figures 2.40-04 is equivalent to 2.40×10^{-4} or .000240. Units of the data are at the top of the column in the table

A data hardness number is required for each entry except those with 0998 and 0999 footnote designations. In the computerized data bank, it will be possible to search for hardness numbers in order to categorize the inaccuracy of data blocks. Hardness number definitions are given in Figure 4. As a general rule, it is useful to consider data hardness in the context of "confidence" and relate this to the 1 to 5 scale.

Footnotes and References use abbreviations where possible to facilitate loading of data into the computer data bank. Appendix A is a list of abbreviations and their definitions. When using exponential numbers such as 1.35×10^{8}, the designation within the footnote will be 1.35E+08, 1.35E08, or 1.35+08.

2. Footnotes and References

Footnotes and references have been classified according to a numbering system which is shown in Figure 5. Note that specific blocks of numbers have been allocated to the various pieces of data assembled. The numbers in Figure 5 indicate which new footnotes follow each individual table. These footnotes are related to the new information generated for the table in question. This will become apparent as the tables are used. The term "general reference" has been applied to any reference which is used in more than one area of the impact data (i.e., for both coal supply and oil supply, natural gas supply, and transportation end use, etc.).

Hardness	Definition*	Example
1	Very Good - Highest confidence. Error probably ≤10 percent. Data well accepted and verified.	Nationwide consumption based on accurate reporting technique.
2	Good - Reputable and accepted. Error probable ≤25 percent.	Data from several major companies used to represent U.S.
3	Fair - Error probably ≤50 percent. Validity may be uncertain due to method of combining or applying data.	Data from one company used to represent U.S.
4	Poor - Low confidence in data. Error probably 100 percent. Validity questionable.	Telecon estimate used in absence of measurement.
5	Very Poor - Validity of data unknown. Error probably within or around an order of magnitude.	Assumption based on related reference. Several Fair or Poor sources combined.

* Error levels cited refer to cases where the data are non-zero. For zero or "negligible" values, the definitions Good, Fair, etc. should be applied to the various hardness levels.

Figure 4. Hardness Number Definitions

	Table No.	Footnote Numbers	Reference Numbers
General References	--	--	0001-0042
Coal National Uncontrolled	1	1000-1099	1001-1080
		1801-1827	--
Coal National Controlled	2	1100-1137	1100-1121
Coal Northwest Uncontrolled	3	1200-1229	1201-1218
		1236-1237	
Coal Northwest Controlled	4	1230-1235	1219-1222
Coal Central Uncontrolled	5	1300-1348	1301
Coal Central Controlled	6	1350-1364	--
Coal Northern Appalachia Uncontrolled	7	1400-1452	--
Coal Northern Appalachia Controlled	8	1455-1472	--
Coal Central Appalachia Uncontrolled	9	1500-1539	--
Coal Central Appalachia Controlled	10	1550-1562	--
Coal Southwest Uncontrolled	11	1600-1622	--
Coal Southwest Controlled	12	1625-1629	--
Oil National Uncontrolled	13	2000-2099	
Oil National Controlled	14	2100-2129	
Oil Domestic On-Shore Uncontrolled	15	2200-2201	2000-2042
Oil Domestic On-Shore Controlled	16	2300-2301	
Oil Domestic Off-Shore Uncontrolled	17	2202-2203	
Oil Domestic Off-Shore Controlled	18	2302-2305	
Oil Imported Canadian Uncontrolled	19	2204-2205	
Oil Imported Canadian Controlled	20	2306-2309	
Oil Imported Middle East Uncontrolled	21	2206-2207	
Oil Imported Middle East Controlled	22	2310-2313	
Oil S.A. Residual Uncontrolled	23	2208-2212	
Oil S.A. Residual Controlled	24	2314-2315	
Natural Gas (all)	25	3000-3061	3000-3010
Electric Power Activity of Fuel Supply--Coal	26	1900-1919	
Electric Power Activity of Fuel Supply--Oil	26	2901-2908	1900-1926
Electric Power Activity of Fuel Supply--Gas	26	3901-3905	
Electric Power Activity of Fuel Supply--Nuclear	26	9600-9619	9600-9601
Residential End Use	27	5001-5035	5101-5118
Commercial	28	5501-5510	5501-5513
Industrial--Paper	29	6500-6506	6501-6504
Industrial--Transportation	29	6701-6704	6701-6708
Industrial--Stone Clay Glass	29	6300-6333	6300-6319
Industrial--Chemicals	29	6100-6134	6100-6118
Industrial--Food	29	6400-6415	6400-6418
Industrial--Primary Metals	29	6600-6611	6600-6606
		6630-6638	6630-6632
Transportation	30	7001-7044	7001-7022

Figure 5. Numbering Classification for Footnotes and References

In addition to the footnotes which are printed text, three other designations are used in the tables. These are defined as follows:

Footnote No.	Definition
0997	Zero or negligible impact for this activity - an appropriate hardness value is required
0998	This impact not applicable to this activity
0999	This value not available - an impact for this activity is assumed to exist

To simplify the citation of references within footnotes, the following format has been used:

Format for References in Footnotes:

(3004,739)	Reference 3004, page 739
(3004,739,742)	Reference 3004, pages 739,742
(3004,739/742)	Reference 3004, pages 739 through 742
(5123,A-9)	Reference 5123, page A-9
(5123,A-9,A-12)	Reference 5123, pages A-9, A-12
(5123,A-9/A-12)	Reference 5123, page A-9 through A-12

Note that a reference citation is always enclosed in parentheses.

Footnotes which follow the tables appear in the exact form that a computer printout will yield. Each footnote indicates the references and other footnotes it is based upon. In this report some minor inconvenience derives from having to refer to a separate list of references located following all of the tables and footnotes. However, in the computerized data bank, footnotes could be printed out followed immediately by the applicable references and first order footnote referrals.

C. Energy Supply

1. Introduction

The energy supply tables and footnotes deal with the quantification of the environmental impacts of each process in the fossil fuel energy supply trajectories based on a process input of the fuel equivalent to 10^{12} Btu/yr. The value of 10^{12} Btu/yr was chosen as a convenient unit for an energy rate. The rate form was chosen to facilitate the use of published data on environmental impacts in which a time factor is involved, such as, for example, emission rates in lb/day for evaporation losses from gasoline storage tanks, impacts related to annual production rates, etc.

The fuels considered in the supply trajectories are the primary fossil fuels and their derivatives and modifications, as follows:

Primary: Coal, oil, natural gas

Derived: Coke, gasoline, jet fuel, kerosene, distillate, residual, liquified petroleum gases (LPG)

Modified for transmission: Liquified natural gas (LNG)

The environmental impacts are developed initially on a national average basis, with regional effects added in subsequent tables. The categorization of regions is shown in Figure 2. Twenty-five tables have been developed in the Energy Supply Section, representing various degrees of environmental control and region of interest. The order of presentation is coal, oil, and natural gas.

Each of the tables is organized as a matrix with the environmental impacts as columns and activities and processes as rows. For each activity on the left of the table, the relevant processes are listed immediately below. In general, the entries in the tables are on a process basis, rather than on an activity basis. As noted earlier, an activity may consist of a single process, or it may consist of a number of processes.

Each table has a related general footnote which gives basic data pertinent to the fuel considered, such as the amount of the fuel equivalent to 10^{12} Btu. It is important to note that all impacts have been derived for a process input of fuel equivalent to 10^{12} Btu/yr. In particular, for the extraction activity, this is interpreted to mean 10^{12} Btu of resource in the ground. Thus impacts for the extraction activity are expressed per 10^{12} Btu in the ground and not per 10^{12} Btu produced or extracted (output of fuel).

A general caution is applicable to all the supply data. Before using any impact expressed in terms of 10^{12} Btu, the reader should read the footnote. Potential misuses of the data can readily be cited. Increasing the plant capacity may not increase the land impact proportionately, since the land use is not necessarily linearly related to the productive capacity of the plant. Doubling the productive capacity doubles the land requirement only if an additional and identical facility is constructed. Caution must be exercised when evaluating the land effects for large multiples of 10^{12} Btu/yr. Similarly, size considerations are important in cost calculations and the footnote will relate how the particular entry has been calculated.

It is important to note the interrelationships between environmental impacts, efficiency, and cost data. Strictly speaking, a specified level of environmental control has associated with it corresponding levels of cost and energy requirements. This is apparent in a comparison of the uncontrolled and controlled environmental tables. However, this is also true within each supply table, as air pollutant data is related to ancillary fuel use, land use is related to solid waste data, etc. Air pollutants associated with the generation of electricity are ascribed to the power plant activity and not at the site of the process which uses the electricity as ancillary fuel.

2. Definition of Uncontrolled and Controlled

All supply tables are designated either controlled or uncontrolled. "Uncontrolled," according to the ground rules adopted in this study, means that impacts are the current national or regional average value. In the absence of current (1972-73) data, impacts typify the use of least stringent environmental controls.

"Controlled" implies that impacts are consistent with the use of control technology which will probably be required and/or available in 5 to 10 years. As an illustration, present laws governing the reclamation of surface mined lands minimally require that effort be made to restore the land. This may include partial backfilling and an attempt at revegetation. However, since the degree and success of reclamation are not mandatory, (for the "uncontrolled" condition) reclamation is not assumed for area stripping operations, and only partial backfilling is assumed for contour mines. In the controlled situation, contour backfilling and revegetation are required for either type of stripping operation. The attainment of this high level of reclamation would require such practices as stockpiling and redistribution of the topsoil, segregation of toxic overburden and seed bed preparation. Generally speaking, the controlled condition incorporates the environmental standards proposed or soon to be implemented by the

Environmental Protection Agency. A more detailed explanation of controlled and uncontrolled as it is related specifically to each process in the fossil fuel supply chain is to be found in the writeups preceding each of the supply tables and in the accompanying table footnotes.

3. Environmental Parameters

In the supply tables, the units for the various environmental impacts are noted above the columns. Since the basis for the tables is the fuel equivalent of 10^{12} Btu/yr, the actual units for the values given in the tables are interpreted as follows:

Water Pollutants:

Acids, bases, dissolved solids, suspended solids, organics:

$$\frac{\text{Tons discharged to water bodies/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{tons}}{10^{12} \text{ Btu}}$$

BOD, COD:

$$\frac{\text{Oxygen demand in tons/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{tons}}{10^{12} \text{ Btu}}$$

Thermal:

$$\frac{\text{Btu discharged to water bodies/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{Btu}}{10^{12} \text{ Btu}}$$

Air Pollutants:

$$\frac{\text{Tons discharged to atmosphere/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{tons}}{10^{12} \text{ Btu}}$$

Solid Waste:

$$\frac{\text{Tons placed on land/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{tons}}{10^{12} \text{ Btu}}$$

Occupational Health:

Deaths: $$\frac{\text{Deaths/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{Deaths}}{10^{12} \text{ Btu}}$$

Injuries: $$\frac{\text{Serious injuries/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{Serious injuries}}{10^{12} \text{ Btu}}$$

Man-days lost: $$\frac{\text{Man-days lost due to serious injuries/yr}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{Man-days lost}}{10^{12} \text{ Btu}}$$

Land:

Fixed: $$\frac{\text{Acres occupied by fixed facilities}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{Acre-yr}}{10^{12} \text{ Btu}}$$

Incremental: $$\frac{\text{Time-averaged incremental acres}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr}} = \frac{\text{Acre-yr}}{10^{12} \text{ Btu}}$$

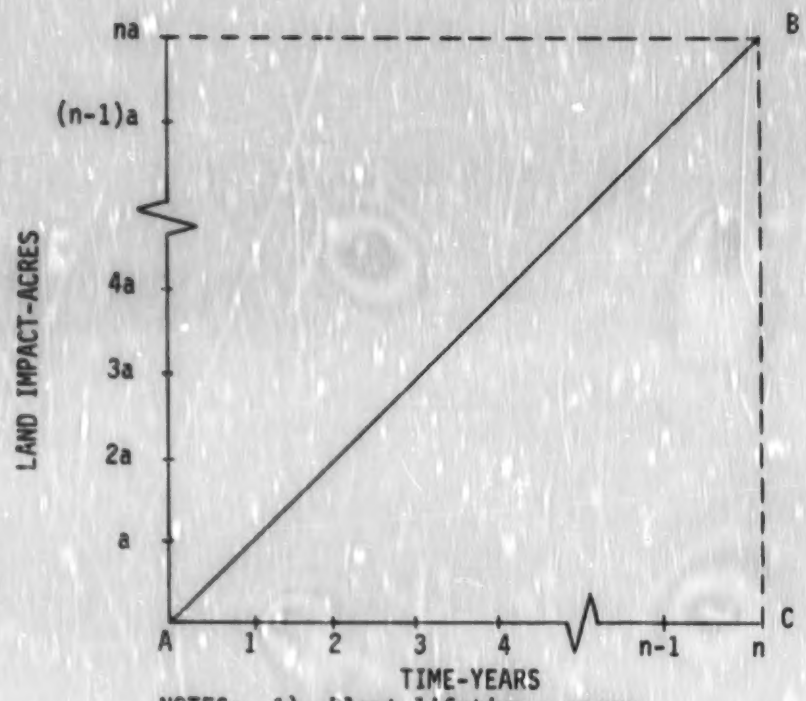
The values for land disturbed shown in the tables are, where applicable, the sum of fixed and time averaged incremental land impacts. As an example, consider a coal processing plant which handles B Btu/yr of coal, occupies A acres, and produces solid waste for disposal occupying an additional a acres/yr. The fixed land impact is defined as:

$$A_f = \frac{A}{B} \text{ in units of } \frac{\text{acre-yr}}{10^{12} \text{ Btu}}$$

The incremental land impact is defined as:

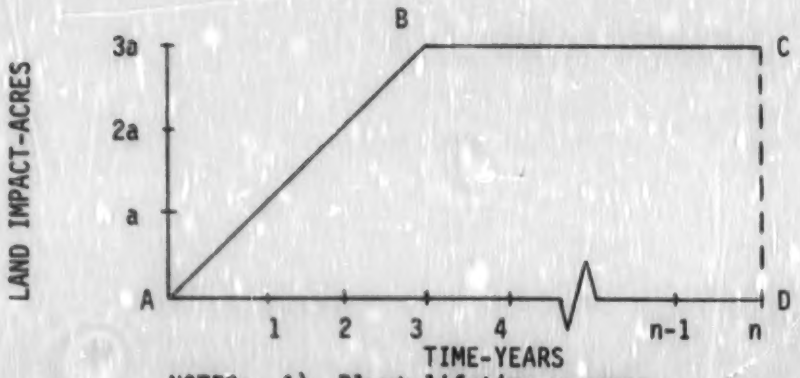
$$A_i = \frac{a}{B} \text{ in units of } \frac{\text{acre}}{10^{12} \text{ Btu}}$$

To sum these land impacts it is first necessary to introduce the units of time, or time average the incremental land impact. Conceptually this represents the average acres of land which will be impacted over the lifetime of the plant. Numerically, the time averaging process will depend on whether or not environmental controls, specifically reclamation of the disturbed land, will be employed. Figures 6 and 7 illustrate the uncontrolled (i.e., unreclaimed) and controlled (reclaimed) environmental conditions as they pertain to the time averaging of incremental land



NOTES: 1) Plant lifetime n years
2) Incremental land impact a acres/yr
3) No reclamation of disturbed land

Figure 6. Uncontrolled Incremental Land Impact



NOTES: 1) Plant lifetime n years
2) Incremental land impact a acres/yr
3) Reclamation of disturbed land with 3 year time lag for revegetation

Figure 7. Controlled Incremental Land Impact

use. As shown in Figure 6, for the uncontrolled plant with an n year lifetime and an incremental land impact of a acres/yr, the total amount of land disrupted after n years would be na acres since the land is not being reclaimed for use. The average land impact over the n year lifetime of the plant is given mathematically by the area of triangle ABC divided by n years, i.e. $\frac{1/2\ (n)(na)}{n}$ or $\frac{(n)}{2}$ a. Hence, the time averaged incremental land impact for the uncontrolled case is defined as:

$$A_{it} = \frac{n}{2}\ \frac{a}{B} \text{ in units of } \frac{\text{acre-yr}}{10^{12}\ \text{Btu}}$$

Figure 7 shows the land impact for the same plant employing reclamation practices to recover the land disrupted by the solid waste. In this example three years was chosen as the time period necessary for reestablishing vegetation. Thus, assuming concurrent reclamation, the land impact curve in Figure 7 levels off after the third year. That is, after the third year, the number of acres impacted remains constant. For each a acres disrupted in any year, an equivalent a acres has been reclaimed (starting three years before). The average land impact over the n year lifetime of the controlled plant would then be given mathematically by area ABCD divided by n years, i.e.,

$$\frac{(1/2(3)3a) + (3a)(n-3)}{n} \text{ or } (3-\frac{9}{2n})a.$$

Hence the time averaged incremental land impact for the controlled case with a three year time lag for revegetation is defined as:

$$A_{it} = (3-\frac{9}{2n})\ \frac{a}{B} \text{ in units of } \frac{\text{acre-yr}}{10^{12}\ \text{Btu}}.$$

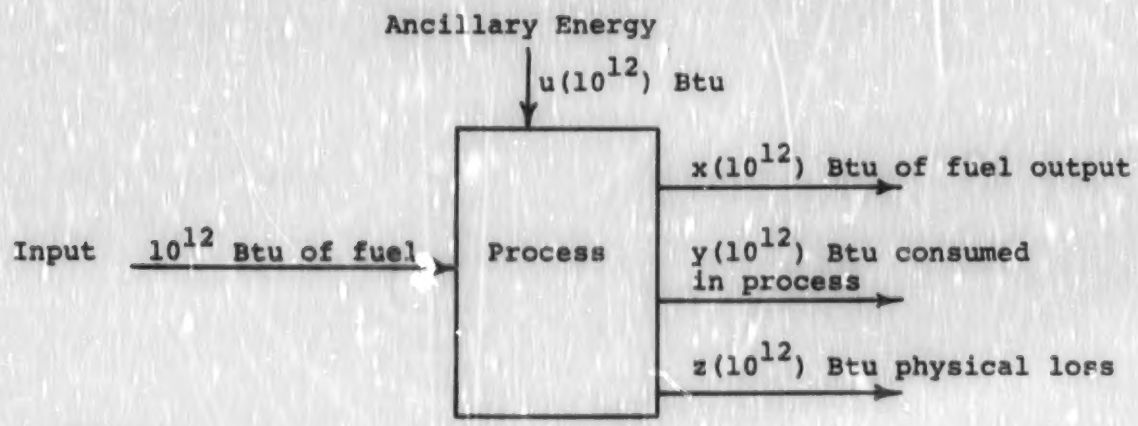
Note that the controlled definition given above is only applicable for those cases where three years is required for reestablishing vegetation. If this time lag changes, obviously so will the time averaging multiplier. Generally the plant lifetime (n) is taken as 25 years. Based on this value the time averaging multiplier for the uncontrolled case ($\frac{n}{2}$) would be 12.5 years, and for the three year time lag controlled case ($3-\frac{9}{2n}$), the multiplier would be 2.82 years.

This time averaged incremental land impact calculation arbitrarily ignores any land impact which could occur beyond the specified lifetime of the facility. Continuing impact from yet unreclaimed land or the remaining structural facilities beyond the expected useful life (n) of those facilities is not considered.

4. Efficiency

The Hittman data tables contain two efficiency related inputs. These are primary efficiency (column 26) and ancillary energy (column 27).

Efficiency definitions can be related to the following diagram:



Where:

$x+y+z = 1$

Primary Efficiency $= x = 1-y-z$

Overall Efficiency $= x-u$ (BNL)

Overall Efficiency $= \frac{x}{1+u}$ (Theoretical)

$$x-u \cong \frac{x}{1+u} \text{ for small } u, \text{ i.e., } u \ll 1$$

If the process separates the input fuel stream into several output fuels, $x(10^{12})$ may be taken as the sum of the energy contents of the output fuels and x as an approximate value for the efficiency of each output fuel.

In some processes there is apt to be confusion as to whether an energy use is classified as ancillary or part of the input flow consumed. In a refinery, refinery gas (which provides energy for many processes) is considered as primary fuel consumed rather than as an ancillary demand. Any use of a fuel derived from the primary input stream remains part of the primary flow.

5. Costs

Cost data expressed in 1972 dollars are included in the uncontrolled and controlled national supply tables in columns 28-30. The total capital or fixed cost for equipment, structures, etc. is annualized at 10 percent per year and shown in column 28. Yearly operating expenses for fuels, maintenance, labor, etc. are given in column 29, while column 30, which represents the total annual cost, is the sum of columns 28 and 29. The units for the economic data are shown below:

Fixed Cost: $$\frac{(\$ \text{ of capital expense}) \times (.10/\text{yr})}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr input}} = \frac{\$}{10^{12} \text{ Btu}}$$

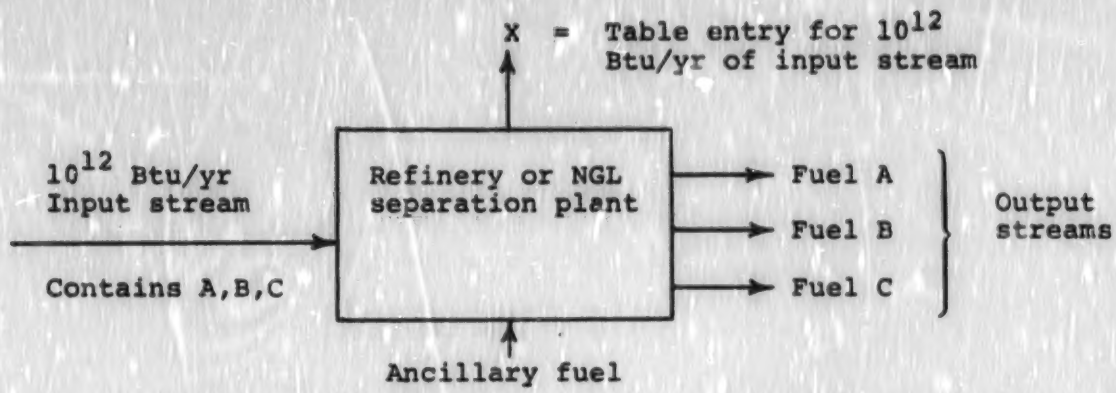
Operating Cost: $$\frac{\$/\text{yr for operating expenses}}{\text{Fuel equivalent to } 10^{12} \text{ Btu/yr input}} = \frac{\$}{10^{12} \text{ Btu}}$$

The 10 percent/yr annualization or "fixed charge rate" (as it is called in the table footnotes) for capital expenses was chosen mainly for convenience and may or may not reflect actual practice within a particular industry. It is convenient to express the capital cost data in this fashion because: 1) it provides some estimate of total annual costs and 2) it allows a quick estimate of total capital cost from the table data by simply increasing the fixed cost by a factor of ten. That is, for a table fixed cost entry of 1.50+05, the total capital cost is 1.50+06 or 1-1/2 million dollars/10^{12} Btu equivalent fuel input.

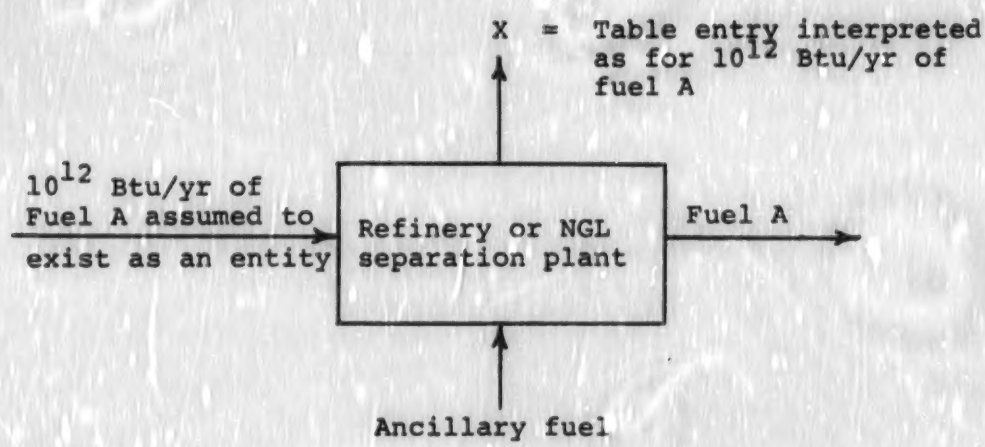
The price of the raw energy resource into a process is not included in any of the cost data. The annual cost data represented in the tables is a major component of the ultimate price level of the fossil fuels delivered. Since the basis for costs is 1972 dollars, table values would have to be adjusted to reflect present-day (1974) costs.

6. Allocation of Table Entries to Process Fuels

The following suggests a technique for allocating tabular impacts to the product fuel mix. A refinery or natural gas processing plant is used as an example. Oil refineries and natural gas processing plants separate input fuel streams into several output fuel streams.



If the data are to be used to construct a trajectory for a particular product fuel, starting at the well head where such fuel does not exist as an entity, the table entries for the processing activity or for activities prior to processing may be used as reasonable approximations for such product fuel.



D. Energy End Use

The end uses of energy have been broken down into the four usually reported categories; residential, commercial, industrial, and transportation. Alternative categorizations exist but these four are convenient because they most often appear in the literature.

From a reporting viewpoint, the end use data format will, at first glance, appear similar to the supply sector. The major difference lies in the units of the data. Rather than air emissions being reported in tons/10^{12} Btu, a typical end use unit is tons emission/ton steel or tons emission/automobile passenger-mile. This technique relates environmental impacts to the end use measure that seems most appropriate. The following definitions will help to clarify end use table differences from the format used for supply.

Measure: (Col.27)	The unit appropriate for the end use at the lowest level of disaggregation. (Example: passenger-mile)
Fuel: (Col.26)	The fuel consumed at the end use. If a particular end use currently consumes significant amounts of more than one type of fuel, then more than one line of data is required. (Example: Residential space heating requires entries for distillate fuel oil, natural gas, and electricity)
Energy: (Col.28)	The Btu per unit measure required for each end use. (Example: Btu/ton-mile)
Multiplier: (Col.29)	The amount of each end use measure for domestic energy consumption. This value is the most recent available, with the year for each multiplier given in Column 30. (Example: The multiplier for piston engine powered general aviation aircraft is 2.4×10^7 hours in 1970)

The product of the multiplier and the energy (Column 29 x Column 28) provides an actual yearly energy use expressed in Btu's. Projections in energy use can be made by varying the multiplier to correspond with the growth or decrease of a particular end use with time. All end use impact data except the Industrial sector, correspond to a particular fuel. The specific fuel used is the link between the end use and supply portions of the data bank.

The product of the multiplier and any one impact value provides the environmental impact measured in tons of emission per year. All end use tables are "uncontrolled" in that the level of control of environmental impacts is representative of very recent or current practice.

When using energy data where the fuel is indicated to be electricity, the energy (Column 28) is expressed in fossil fuel equivalent to electricity use. The Btu equivalent is measured at the input to the power plant using a conversion factor of 10,239 Btu/Kw-hr. It is important to note this so that conversion losses are not double counted when complete trajectories are constructed.

A quick review of the end use tables will establish that most of the environmental impact entries are for air emissions. Most other entries use a 0998 footnote meaning that the impact is not applicable to the particular end use. For the most part this non-applicability means that any environmental impacts which may occur are not energy related or no rational technique exists to distinguish what portion of the total impact is energy related. As an example of this, consider the deaths due to the automobile. The primary purpose of the automobile is to transport people not to use energy. The number of deaths cannot be attributed fairly and directly to energy use in the same way as can the air emissions from the engine. The general guideline used in the end use table preparation is that any impacts recorded must be clearly attributable to energy use.

As with the supply tables, the user of Tables 27 through 30 must exercise caution in applying any value derived from a table. The user should first read the footnote to understand the context of the information.

E. Energy Model and Data Base (EMDB)

The data presented in this report have been entered in a computerized data base (MERES). Brookhaven National Laboratory has combined this data base with a number of data management and energy modeling programs to form a complete package known as the Energy Model and Data Base, or EMDB. Brookhaven National Laboratory (BNL) will continue to update, maintain, and improve the data base and its associated programs.

The EMDB is presently available on the Control Data Corporation computer facility at BNL. It will be directly accessible via a telephone connection and terminal to remote users. In writing the computer programs for the EMDB, care has been taken to insure that the programs would be easily transferrable to other computer facilities.

The basic unit of storage in the EMDB is a particular supply or utilization (end use) process, which corresponds to the complete set of numeric values contained in a single row of the tables in this report. Each basic process storage unit contains all of the numeric values (and their hardness factors) as well as the full documentation for the number set. The specific process desired is identified by a string of mnemonics which have different forms for supply and utilization processes. These string forms are as follows:

SUPPLY: /RESOURCE/ACTIVITY/PROCESS/REGION/CONTROL/.

UTILIZATION: /SECTOR/ACTIVITY/PROCESS/FUEL/CONTROL/.

The mnemonics for each supply activity and process can be found in the left-most column of each supply table (Tables 1-26). Likewise, the mnemonics for each utilization activity and process can be found in the left-most column of each utilization (end use) table (Tables 27-30). The accessing codes are further detailed in Figure 8 (supply), and Figure 9 (utilization).

One of the programs associated with the EMDB permits the calculation of national energy flows and the impacts of such flows on resource consumption, pollutant emissions, and dollar costs. This program, called the Energy System Network Simulator (ESNS), considers the energy system as a set of process links in a network representation. These network process links can be associated with particular process blocks (both supply and utilization) in the EMDB. An interfacing program is provided which draws numeric values from the data base and makes them available for flow calculation through the network. Capabilities are also provided for modifying any numeric value for input to the ESNS and for adding new links to the ESNS network. With these capabilities, the effects of various simulation scenarios can be calculated.

Order of mnemonic string identifier corresponding to a supply table row:

/RESOURCE/ACTIVITY/PROCESS/REGION/CONTROL/.

Identifier		Mnemonic	
Resource:	Coal	COAL	
	Oil	OIL	
	Natural Gas	GAS	
Activity:		(See Supply Table)	
Process:		(See supply Table)	
Region:	National	NATL	Coal
	Northwest	NW	Coal
	Southwest	SW	Coal
	Central	CNTRL	Coal
	Northern Appalachia	NAPPL	Coal
	Central Appalachia	CAPPL	Coal
	Domestic Onshore	ONSHR	Oil
	Domestic Offshore	OFSHR	Oil
	Imported Middle East Crude	MECRD	Oil
	Imported Canadian Crude	CANAD	Oil
	Imported South American Residual	SARSD	Oil
	Onshore	ONSHR	Gas
	Offshore	OFSHR	Gas
	Canadian	CANAD	Gas
Control:	Controlled	CONTL	
	Uncontrolled	UNCON	

Figure 8. Data Access Code for Supply

Order of mnemonic string identifier corresponding to an end use table row:

/SECTOR/ACTIVITY/PROCESS/FUEL/CONTROL/.

Identifier		Mnemonic
Sector:	Residential	RSDTL
	Commercial	COMML
	Industrial	INDST
	Transportation	TRNSP
Activity:		(See End Use Table)
Process:		(See End Use Table)
Fuel:	Gasoline	GASO
	Distillate	DSTL
	Residual	RESID
	Natural Gas	GAS
	Coal	COAL
	Electricity	ELECT
	Petroleum Coke	PCOKE
	Coke	COKE
	Liquified Petroleum Gas	LPG
	Asphalt	ASPH
	Lubricant	LUBE
	Jet	JET
	Aggregate of all fuels	AGGR
Control:	Controlled	CONTL
	Uncontrolled	UNCON

Figure 9. Data Access Code for Utilization (End Use)

III. COAL SUPPLY

A. Introduction

The environmental impacts resulting from coal mining are quantified and based on an input of 10^{12} Btu/yr for each process in the supply chain. The impacts are determined on a national and regional basis, and for two conditions of environmental control.

It is recommended that the footnotes be read before using and interpreting the data presented. Potential misuses are easy to cite. As an example, the data presented in this report for auger mining considers steep slopes with no previous contour stripping. In reality, much of the auger mining follows contour stripping operations and would not produce all of the impacts given in the tables. Other obvious pitfalls are misinterpretations of the data and drawing erroneous conclusions. Underground mining by the longwall method shows a much larger land impact due to subsidence than does mining by conventional or room and pillar methods. However, since subsidence will be more uniform for longwall mining, the land disruption may be less severe. No weighting factor was applied to the data to reflect this qualitative judgement. A comparison of uncontrolled and controlled coal supply tables indicates acid mine drainage and treatment for its elimination. However, only acid mine drainage from active coal mines was considered in this analysis, and it would be incorrect to infer that all acid mine drainage will be eliminated by this treatment. At present, the major source of acid mine drainage is from inactive underground coal mines.

The regional analyses cover five geographic areas: (1) Northwest - Powder River Basin, (2) Southwest - New Mexico and in particular the San Juan Basin, (3) Central - Illinois and Indiana, (4) Northern Appalachia - central and western Pennsylvania, Ohio and northern West Virginia, and (5) Central Appalachia - southern West Virginia, Virginia and eastern Kentucky. Each of these five regions is unique in terms of coal characteristics, mining techniques, reclamation problems, or a combination of these. Aside from the singular nature of these regions, they are also either the principal producers, or contain a significant percentage of the nation's coal reserves. Figure 10 summarizes coal properties used for the national and regional analyses.

At the activity level, the supply chain for coal includes extraction, transportation, processing, distribution, storage, and coke conversion. A discussion of each of the activities and their subsequent processes follows.

	Caloric Content (Btu/lb)	10^{12} Btu Equivalent (Tons)	Sulfur Content (%)	Ash Content (%)	Coal Density (lb/cf)	Ave. Coal Seam Thickness (ft)
Northwest	8780	57000	0.85	6.77	81	39-Surf.
Central	10600	47200	2.92	8.9	81	4.8-Surf. 6.8-Under.
Northern Appalachia	11800	42400	3.07	14.7	85	3.9-Surf. 5.1-Under.
Central Appalachia	12100	41000	0.93	11.2	85	4.2-Surf. 4.7-Under.
Southwest	9820	51000	0.6	15.7	81	11.8-Surf.
National Average	12180	41000	2.59	12.53	81	5.2-Surf. 5.3-Under.

Figure 10. National and Regional Coal Analyses

1. Extraction

At the process level, the extraction phase is categorized by the mining techniques currently being employed. For under=-ground mining this includes room and pillar, and longwall mining. Surface mining covers both contour and area stripping. Augering, another form of surface mining, is also included. Due to a lack of environmental data, longwall stripping was not investigated. Presently, a site in northern West Virginia is being selected for a demonstration project on longwall stripping.

All of the mining methods listed above are analyzed on the national level. For the regional analyses some of the methods are excluded because they either are not employed in the specific region, or production by the methods is relatively low. As an illustration, only area stripping was included for the Northwest. Stripping on steeper slopes has been prohibited by legislation, thus eliminating contour stripping and augering. Underground mining is not practiced in the Powder River Basin.

2. Transportation

The transportation phase applies to the haulage of the coal from the working face to the tipple. Three modes of transport are studied: (1) trucking - primarily associated with surface mines, (2) mine rails (or cars), and (3) conveyors. As analyzed, the latter two modes of transportation are applicable to under-ground mines. Although rails and conveyors are used at surface mines, the primary method for movement of coal is by trucks.

All modes of transportation are investigated on the national level, but only those applicable are included in the regional analyses.

3. Processing

At the process level this activity is divided into three fundamental preparation plants: (1) breaking and sizing plant, (2) utility (steam) coal plant, and (3) metallurgical coal plant.

Coal that is mined clean (meeting market requirements) is generally just crushed and screened before shipping to the con-sumer. The breaking and sizing plant is the simplest of the three plants considered. No washing of the coal is performed.

The utility (steam) coal plant washes the raw coal to meet the specifications of the steam electric utilities market. The raw coal is crushed to a 1.5 in. topsize and the coal greater than three-eighth in. in size is assumed to be washed in a dense medium bath at a specific gravity of separation of 1.6.

The metallurgical coal plant is the most complex of the three plants analyzed, since the requirements for the coking industry are the most stringent - less than two percent sulfur, eight percent ash and about eight percent moisture. The raw coal is crushed to a 1.5 in. topsize, and the coal greater than three-eighth in. size is washed in a dense medium bath at a specific gravity of separation of 1.4. The intermediate size coal (three-eighth in. x 28 mesh size fraction) is processed in concentrating tables at a specific gravity of about 1.6. The coal fines (less than 28 mesh in size) are cleaned by froth flotation. The intermediate and fine size coals are then thermally dried prior to shipping.

The unit processes that make up the preparation plants are also considered in the national and regional "uncontrolled" analyses. They are disregarded in the "controlled" situation because the environmental impacts do not change. Aside from the atmospheric discharges, the controls are applied at the "end-of-pipe." Thus, the controls are applicable to the plants, rather than the individual processes that comprise the plant.

Since the primary focus of the regional analysis is on coals for the utility market, the metallurgical coal plants were not considered for the regions. In those regions (central Appalachia, northwest and southwest) where the average run-of-mine coal is relatively clean, only the breaking and sizing plant are included. It should be noted that coal preparation beyond crushing and sizing is not foreseen.

4. Distribution

This activity considers the shipment of the coal from the mines or preparation plant to the point of consumption. The modes of transportation included are: (1) unit train, (2) mixed train (where the load of any one train is not composed solely of coal), (3) trucking, (4) pipeline, and (5) conveyor.

Again, as for all other activities, only the predominant modes of transportation utilized in a specific region are considered in the regional analysis. The transport distances are adjusted to reflect the mileage from the mines to the major markets for each region.

5. Conversion

This activity includes only coke production. Both slot and beehive ovens are considered. The "controlled" case analysis considers only slot ovens since environment controls on beehive ovens have received much less attention and are, at present, poorly defined. Coke production by beehive ovens is less than one percent of the total coke produced in this country.

B. Impact Data Tables and Footnotes

		UNCONTROLLED FUEL	REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		COAL	NATIONAL	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL 12)												AIR POLLUTANTS			
						DISSOLVED SOLIDS													
ROW	MNEMONIC	ACTIVITY PROCESS		ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12} BTU	PARTICULATES	NO_x	SO_x	HYDROCARBONS
1	EXTRC	EXTRACTION																	
2	UNDER	UNDERGROUND																	
3	LONGW	LONG WALL		0.63+01 5 1018	0000	0000	0000	6.81+02 5 1018	6.81+02 5	1.05+02 5 1018	0000	6.81+02 5	0000	0.00+00 1 0007	0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 [illegible]
4	ROOMP	ROOM & PILLAR		2.98+01 5 1018	0000	0000	0000	3.06+02 5 1018	3.06+02 5	2.04+02 5 1018	0000	3.06+02 5	0000	0.00+00 1 0007	0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 [illegible]
5	AUGER	AUGER		3.77+00 5 1018	0000	0000	0000	2.50+01 5 1018	2.50+01 5	0.74+00 4 1018	0000	6.00+03 4	0000	0.00+00 1 0007	0000	4.06-02 5 1015	1.15+00 5 1015	6.40-02 5 1015	1.15-01 5 [illegible]
6	SURFC	SURFACE																	
7	STRIP	<15° SLOPE		8.11+00 5 1020	0000	0000	0000	6.06+01 5 1020	6.06+01 5	1.20+00 4 1020	0000	4.50+01 5	0000	0.00+00 1 0007	0000	6.23-02 5 1000	1.23+00 5 1000	8.99-02 5 1000	1.23-01 5 [illegible]
8	STRIP	>15° SLOPE		2.30+00 3 1001	0000	0000	0000	4.35+01 5 1001	4.35+01 5	2.06-01 4 1001	0000	2.12+03 4	0000	0.00+00 1 0007	0000	6.90-02 5 1013	1.96+00 5 1013	1.63-01 5 1013	1.96-01 5 [illegible]
9	TRANS	TRANSPORTATION																	
10	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	2.60+01 4 1003	0000	2.60+01 4	0000	0000	0000	2.80-02 5 1003	6.56-01 5 1003	4.77-02 5 1003	6.56-02 5 [illegible]
11	CONVY	CONVEYOR		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 [illegible]
12	MINE RAIL	MINE RAIL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+01 2 1002	0.00+00 2 1002	0.0000 2 1002	0.00+00 2 [illegible]
13	PROCS	PROCESSING																	
14	PRIMB	PRIMARY BREAKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000	0000	[illegible]
15	ROUGH	ROUGH CLEANING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000	0000	[illegible]
16	RSIZE	RAW COAL SIZING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000	0000	[illegible]
17	DMEDC	DENSE MEDIA (COARSE)		0000	0000	0000	0000	0000	0000	4.10+01 4 1020	0000	4.10+01 4	0000	0.00+00 1 0007	0000	0000	0000	0000	[illegible]
18	TABLE	TABLES (INTERMEDIATE)		0000	0000	0000	0000	0000	0000	4.11+01 4 1021	0000	4.10+01 4	0000	0.00+00 1 0007	0000	0000	0000	0000	[illegible]
19	FROTH	FROTH FLOTATION (FINES)		0000	0000	0000	0000	0000	0000	1.23-02 4 1022	0000	1.23-02 4	0000	0.00+00 1 0007	0000	0000	0000	0000	[illegible]
20	THDRY	THERMAL DRYING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.27+02 3 1002	2.87+00 2 1002	2.25-01 2 1002	[illegible]
21	MIXING	MIXING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	[illegible]
22																			
23	BRKRS	BREAKING & SIZING		0000	0000	0000	0000	0.00+00 2 1070	0.00+00 2	0.00+00 2 1070	0000	0.00+00 2	0000	0.00+00 1 0007	0000	0.00+00 2 1077	0000	0000	[illegible]
24	STEAM	STEAM COAL PLANT		1.30+01 5 [illegible]	0000	0000	0000	3.72+01 5 1073	3.72+01 5	5.K+01 5 1073	0000	5.02+01 5	0000	0.00+00 1 0007	0000	1.38+00 3 1074	1.22-01 3 1074	2.37+00 3 1074	7.52-01 3 [illegible]
25	METLU	METALLURG. COAL PLANT		4.20+01 5 1015	0000	0000	0000	8.06+01 5 1015	8.06+01 5	1.87+02 5 1015	0000	2.67+02 5	0000	0.00+00 1 0007	0000	5.20+01 3 1014	2.06+00 3 1014	5.21+00 3 1014	1.71+00 3 [illegible]
26	DISTR	DISTRIBUTION																	
27	UNIT T	UNIT TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.77+01 4 1000	3.66+00 3 1001	3.35+00 3 1001	2.58+00 3 [illegible]
28	MIXT	MIXED TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	5.18+01 4 1007	1.05+00 3 1007	2.65+00 3 1007	2.08+00 3 [illegible]
29	BARGE	RIVER BARGE		0000	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1.76+01 4 1000	5.80-01 3 1000	7.35-01 3 1000	6.45-01 3 [illegible]
30	PIPEL	PIPELINE SLURRY		0.00+00 1 1026	0.00+00 1 1026	0.00+00 1 1026	0.00+00 1 1026	0.00+00 1 1026	0.00+00 1	0.00+00 2 1026	0.00+00 1 1026	0.00+00 1	0.00+00 1 1026	0.00+00 1 1026	0.00+00 1 1026	0000	0000	0000	[illegible]
31	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.64-01 4 1000	1.22+00 4 1000	8.91-02 4 1000	1.22-01 4 [illegible]
32	CONVY	CONVEYORS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0000	0000	[illegible]
33	STORA	STORAGE																	
34	ABGND	ABOVE GROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000	0000	[illegible]
35	UGND	UNDERGROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000	0000	[illegible]
36	BLOS	SILO OR BIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible]
37	CONVR	CONVERSION																	
38	COKEP	COKE PRODUCTION																	
39	SLOT	SLOT OVENS		0000	0000	0000	0000	1.23+01 2 1034	1.23+01 2	0.00+00 2 1034	1.03+01 2 1034	2.26+01 2	2.06+01 2 1034	0000	0.00+00 1 1034	5.03+01 3 1028	7.76-01 3 1028	1.85+02 3 1028	8.21+01 3 [illegible]
40	BEEH	BEEHIVES		0000	0000	0000	0000	1.61+00 2 1050	1.61+00 2	6.45+00 2 1050	1.17+01 2 1050	9.50+00 2	7.47-01 2 1050	0000	0.00+00 1 1050	3.00+03 3 1028	0.00+00 3 1028	0.00+00 3 1028	1.56+02 3 [illegible]
41																			
42																			
43																			
44																			
45																			
46																			
47																			
48																			
49																			
50																			

OTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

HITTMAN

	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						COST (DOLLARS/10^{12} BTU)			
	PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	FIXED COST	OPERATING COST	TOTAL COST	ROW
	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1			1.25+02 1 1023	5.70+00 1 1023	3.11+00 1 1023							1
	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1	2.00+00 2 1021	2.00+02 2 1030	0000	0000	0000							2
	6.04+02 5 1015	1.15+00 5 1015	0.60+02 5 1015	1.15+01 5 1015	7.00+01 5 1015	1.67+02 5 1015	2.11+00 5	1.63+00 2 1021	1.27+02 2 1022	0000	0000	0000	1070	0.00+01 1 1000	5.00+00 2 1027	0000	0000	0000	3
	4.23+02 5 1000	1.23+00 5 1000	0.29+02 5 1000	1.23+01 5 1000	7.49+01 5 1000	2.00+02 5 1000	2.26+00 5	4.13+04 5 1070	5.11+01 5 1070	2.00+03 2 1023	9.25+02 2 1023	1.66+00 2 1023	1070	5.70+01 1 1000	4.97+00 2 1027	2.00+04 4 1000	1.30+01 4 1000	1.50+05 3 1000	4
	6.90+02 5 1013	1.98+00 5 1013	1.63+01 5 1013	1.95+01 5 1013	1.19+00 5 1013	3.15+02 5 1013	3.59+00 5	3.67+02 2 1004	5.60+01 2 1001	5.33+01 1 1023	1.43+01 1 1023	5.40+00 1 1023	1000	4.44+01 1 1002	6.03+00 2 1010	1.66+05 3 1006	7.06+04 3 1006	1.11+05 3	5
								3.65+05 3 1030	1.56+02 3 1027	0000	0000	0000	1001	4.10+01 1 1004	5.05+00 2 1009	1.40+04 3 1007	2.92+04 1 1007	1.03+04 3	6
										0000	0000	0000	1001	8.00+01 1 1000	2.97+10 4 1004	1.40+04 1 1006	7.72+04 3 1000	1.12+05 3	7
	2.30+01 5 1003	6.58+01 5 1003	4.77+02 5 1003	8.05+02 5 1003	4.00+01 5 1003	1.67+02 5 1003	1.26+00 5		7.12+01 2 1004	2.06+03 1 1030	1.19+01 1 1030	5.70+00 1 1030							8
	0.00+00 2 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1	0000	0.00+00 2 1012	0000	0000	0000	1002	1.00+00 1 1000	6.05+00 5 1004	3.50+03 2 1000	6.55+03 2 1000	0.51+01 3	9
	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 1	0000	0.00+00 2 1042	0000	0000	0000	1002	1.00+00 1 1000	2.30+00 4 1000	4.00+02 3 1000	1.25+03 3 1000	1.01+03 3	10
	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2 0000	0.00+00 1 0000	0000	6.20+04 1 1011	2.50+02 1 1011	1.02+00 1 1011	1002	1.00+00 1 1000	0000	0000	0000	0000	11
	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2 0000	2.46+00 4 1000	0000	0000	0000	0000	1002	1.00+00 1 1000	1.00+00 2 1000	0000	0000	0000	12
	2.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2 0000	0.00+00 1 0000	0000	0000	0000	0000	1002	1.00+00 1 1000	1.00+00 2 1000	0000	0000	0000	13
	0000	0000	0000	0000	0000	0000	0.00+00 2 0000	0.00+00 1 0000	0000	0000	0000	0000	1002	1.00+00 1 1000	0000	0000	0000	0000	14
	0000	0000	0000	0000	0000	0000	0000	9.15+03 2 1017	0000	0000	0000	0000	1002	1.00+00 1 1000	0000	0000	0000	0000	15
	0000	0000	0000	0000	0000	0000	0000	5.76+03 2 1010	0000	0000	0000	0000	1002	7.00+01 2 1000	0000	0000	0000	0000	16
	1.21+02 5 1002	2.67+00 2 1002	1.25+01 2 1002	0000	0000	0000	0000	8.20+03 3 1010	0000	0000	0000	0000	1002	6.50+01 2 1000	0000	0000	0000	0000	17
	0.00+00 1 1007	0000	0000	0000	0000	0000	1.30+02 3	0.00+00 1 1025	0000	0000	0000	0000	1002	6.00+01 2 1000	0000	0000	0000	0000	18
							0.00+00 1 1007	0000	0000	0000	0000	0000	1002	1.00+00 1 1007	7.50+00 2 1010	2.10+01 2 1010	2.40+03 2 1010	8.70+03 2	20
	0.00+00 2 1077	0000	0000	0000	0000	0000	0.00+00 2	2.46+00 4 1010	7.70+01 4 1012	0000	0000	0000	1002	1.00+00 1 1000	0000	0000	0000	0000	21
	1.56+00 3 1076	1.82+01 3 1076	2.37+00 3 1076	1.92+01 3 1076	4.75+00 3 1076	0000	1.03+01 3	3.75+03 3 1012	2.67+00 3 1077	0000	0000	0000	1002	1.00+00 1 1000	0000	5.00+02 4 1010	1.05+03 4 1010	2.20+03 4	22
	5.20+01 3 1014	2.00+00 3 1014	5.21+00 2 1014	1.11+00 3 1014	1.02+01 3 1014	0000	7.20+01 3	0.11+03 3 1013	3.50+00 3 1013	0000	0000	0000	1002	6.40+01 2 1000	2.13+00 4 1000	2.00+03 4 1000	6.00+03 4 1010	1.10+06 4	23
	1.77+01 4 1005	3.46+00 3 1005	3.36+00 3 1005	2.50+00 3 1005	3.01+00 3 1005	5.67+01 3 1005	3.16+01 3	0000	3.30+01 2 1027	0000	0000	0000	1002	6.52+01 2 1000	2.13+00 4 1000	6.07+03 4 1010	1.10+06 4 1010	1.00+03 4	24
	3.30+01 4 1007	3.05+00 5 1007	3.90+00 5 1007	2.00+00 5 1007	2.85+00 5 1007	4.46+01 5 1007	6.49+01 5	0.00 3 1027	6.10+02 2 1033	6.05+01 2 1033	5.90+01 2 1033		1002	1.00+00 2 1001	1.63+10 4 1000	5.10+03 3 1000	7.00+04 3 1002	6.69+04 2 1002	26
	1.76+01 4 1000	6.80+01 3 1000	7.18+01 3 1000	6.43+01 3 1000	5.90+01 3 1000	3.46+02 3 1000	1.50+01 3	0000	1.03+03 2 1033	3.65+01 2 1033	5.05+00 2 1033		1002	9.70+01 3 1001	1.12+16 5 1000	6.26+03 3 1000	1.05+05 3 1001	1.56+00 2 1000	27
	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1002	1.00+00 3 1001	7.70+00 3 1000	6.45+03 3 1001	3.50+05 3 1001	7.40+00 2	28
	1.64+01 6 1000	1.22+00 6 1000	6.93+02 4 1000	1.72+01 6 1000	7.43+01 6 1000	3.16+02 4 1000	1.06+01 6	0000	1.56+00 2 1000	3.36+02 3 1001	6.02+01 3 1001	6.50+01 3 1001	1002	9.00+01 2 1002	7.00+00 2 1000	6.05+06 2 1000	6.00+04 2 1000	6.03+04 2	29
	0.00+00 1 1012	0000	0000	0000	0000	0000	0.00+00 1 0000	0000	2.70+01 3 1014	6.60+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	1.00+00 3 1001	8.17+00 6 1000	1.01+04 3 1007	1.01+06 3 1007	1.01+06 2	30
	0000	0000	0000	0000	0000	0000	0000	0000	7.02+01 2 1031	0.00+00 1 0007	3.50+00 1 0007	0.00+00 1 0007	1002	1.00+00 3 1001	3.01+00 6 1000	1.01+04 6 1000	1.00+04 6	1.00+04 6	31
	0000	0000	0000	0000	0000	0000	0000	0000	7.02+01 2 1031	0.00+00 1 0007	6.00+00 1 0007	0.00+00 1 0007	1002	6.00+01 2 1007	1.00+00 1 1000	0.00+00 1 1000	1.10+04 6 1000	1.21+04 5	32
	0000	0000	0000	0000	0000	0000	0000	0000	1.56+01 2 1032	0.00+00 1 0007	6.00+00 1 0007	0.00+00 1 0007	1002	6.00+01 2 1007	1.00+00 1 1000	0.00+00 1 1000	1.10+04 5 1000	1.21+04 5	33
													1002	6.00+01 2 1007	1.00+00 1 1000	1.00+00 1 1000	1.10+04 5 1000	1.21+04 5	34
													1002	6.00+01 2 1007	1.00+00 1 1000	1.11+00 5 1000	1.10+04 5 1000	1.22+04 5	35
	5.03+01 3 1020	7.70+01 3 1020	1.05+02 3 1020	8.11+01 3 1020	2.47+01 3 1020	3.51+00 3 1020	3.70+02 3												36
	0.00+03 3 1020	0.00+00 3 1020	0.00+00 1 1020	1.50+02 3 1020	1.00+01 3 1020	1.00+01 3 1020	4.11+03 3	1.71+01 3 1020	1.30+00 2 1030	3.50+03 1 1000	0.00+03 1 1000	2.50+01 1 1000	1002	6.00+01 2 1000	0.00+00 1 1000	0000	0000	2.52+04 1 1000	37
								0.00+00 3 1020	0.00+01 3 1000	1.27+03 1 1000	5.03+01 1 1000	1.04+00 1 1000	1000	5.01+01 2 1000	0.00+00 1 1000	0.00	0000	1.00+03 1 1000	38
																			39
																			40
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																			50

TABLE 1. ENVIRONMENTAL IMPACTS, EFFICIENCY AND COST FOR UNCONTROLLED NATIONAL COAL SUPPLY

FOOTNOTES FOR TABLE 1

1000

THE AVERAGE CALORIC CONTENT OF COAL DOMESTICALLY PRODUCED IN THE UNITED STATES IN 1971 WAS 12,180 BTU/LB OF COAL (1004,9). THUS, 1.0E12 BTU OF ENERGY IS EQUIVALENT TO 41,000 T OF COAL. THE MEAN DENSITY OF COAL IS APPROXIMATELY 81 LB/CF (1050). THE BASIS OF ALL COMPUTATION IS ON AN ENERGY INPUT OF 1.0E12 BTU.

1001

THE AVERAGE SEAM THICKNESS OF COAL SURFACE MINED IN THE UNITED STATES IN 1965 (THE LATEST SUCH INFORMATION AVAILABLE) WAS 5.2 FT. (1017,6).

IT IS ASSUMED THAT SURFACE MINING ON SLOPES LESS THAN 15 DEGREES EMPLOYS THE AREA METHOD. THIS MAY NOT BE COMPLETELY ACCURATE IN THAT CONTOUR MINING IS AT TIMES EMPLOYED ON SLOPES AROUND 12 DEGREES.

SINCE NOT ALL STATES, WHERE STRIP MINING IS PRACTICED, HAVE STRINGENT RECLAMATION LAWS, IT HAS BEEN ASSUMED THAT RECLAMATION IS NOT PRACTICED.

THUS, FOR A COAL DENSITY OF 81 LB/CF, 4.47 AC OF LAND IS OVERTURNED PER 1.0E12 BTU IN. THE AVERAGE LIFE OF A LARGE MINE IS APPROXIMATELY 25 YR WITH A PRODUCTIVE CAPACITY OF ABOUT 50 MMT (1018). HENCE, THE TIME AVERAGED LAND IMPACT IS 55.9 AC-YR/1.0E12 BTU IN.
IN A PILE 30 FT HIGH, THE SOLID WASTE WILL OCCUPY .133 AC-YR/1.0E12 BTU IN (FOOTNOTE 1009, SOLID WASTE PRODUCTION).

1002

OF THE TOTAL TONNAGE OF COAL SUBJECTED TO THERMAL DRYING 67P IS DRIED IN FLUIDIZED BEDS, 11P BY FLASH DRIERS, AND 22P BY MULTILOUVER TYPE DRIERS (ASSUMING EMISSIONS ARE SIMILAR FOR ALL OTHER EQUIPMENT NOT PREVIOUSLY ACCOUNTED FOR) (1004,46). ASSUMING A CYCLONE WITH A 70P COLLECTION EFFICIENCY IS UTILIZED, THE EMISSIONS ARE AS FOLLOWS (0002,8-10)

	PARTICULATES, T/1.0E12 BTU
FLUIDIZED BED	82.5
MULTILOUVER	33.9
FLASH	10.8
TOTAL	127.2

IT SHOULD BE NOTED THAT 70P, 30P, AND 4P OF THE COAL EXTRACTED BY UNDERGROUND TECHNIQUES, SURFACE MINING, AND AUGERING, RESPECTIVELY, ARE SUBJECTED TO MECHANICAL CLEANING, AND OF THE TONNAGE CLEANED ABOUT 20P IS THERMALLY DRIED (1004, 47, 50). THE CRUSHING, SCREENING, OR SIZING OF COAL ARE MINOR SOURCES OF DUST EMISSIONS (0002).

1003

AVERAGE HAULAGE DISTANCE FROM STRIP MINE TO TIPPLE IS 5.3 MI (0001,344). THE TRUCK CAPACITY IS 100 T. THE FUEL CONSUMPTION RATE IS ASSUMED TO BE 7 GAL/1000 TMI (0002,3-7). ASSUMING A GROSS TO NET WEIGHT RATIO OF 2.5/1 FOR THE TRUCKS, THE TRIP FROM MINE TO TIPPLE IS 875 TMI AND THE RETURN TRIP 355 TMI. SINCE 410 TRIPS ARE REQUIRED TO HAUL THE 1.0E12 BTU EQUIVALENT T, 3530 GAL OF DIESEL FUEL ARE CONSUMED. THE EMISSION

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BREAKDOWN FOR A DIESEL POWERED TRUCK IS GIVEN IN (0002,3-7). 999
DUSTING FROM HAULAGE ROADS IS ASSUMED TO BE CONTROLLED BY 1099
WATERING DOWN THE ROADS. 1199
1299

NOTE: THE EMISSIONS ARE MAINLY ASSOCIATED WITH SURFACE AND 1399
AUGER MINES. IN THE CASE OF MOST UNDERGROUND MINES THE PREPAR-1499
ATION PLANT (OR TIPPLE) IS LOCATED AT MINE-MOUTH AND HAULAGE 1599
DISTANCE IS MINIMAL. HAULAGE IS GENERALLY ACCOMPLISHED BY 1699
CONVEYORS OR RAIL CARS. 1799

1004 199

THE DATA FROM STUDIES CONDUCTED IN EASTERN KENTUCKY (1024,1031, 299
1032,1033,1034) INDICATE AN AVERAGE HAULAGE ROAD RIGHT-OF-WAY 399
OF 53 FT (6.4 AC/MI). THE MEAN DISTANCE FROM MINE TO TIPPLE IS 499
5.3 MI (0001,334). HENCE, 33.9 AC OF LAND IS UTILIZED BY THE 599
ROADS. ASSUMING AN ANNUAL PRODUCTION FROM THE MINE OF 2 MMT 699
(FOOTNOTE 1022), 2.05P OF THE HAULAGE ROAD USAGE IS ATTRIBUTED 799
TO THE TRANSPORT OF 1.0E12 BTU EQUIVALENT T. THE LAND IMPACT 899
IS THEREFORE 0.712 AC-YR/1.0E12 BTU IN. 999

1005 199

IN GENERAL, A UNIT TRAIN HAULS 10,000 T OF COAL PER TRIP (1005,33) 299
AND UTILIZES THE EQUIVALENT OF 4, 2400 HP DIESEL LOCOMOTIVES 399
(FROM DATA ON MATTHEWS MINE IN (1006)). 499
ENERGY CONSUMPTION BY FREIGHT TRAINS, ASSUMED TO APPLY AS 599
WELL TO UNIT TRAINS, IS 690 BTU/TMI (FOOTNOTE 7013), OR 699
0.005 GAL DIESEL FUEL/TMI (5.86E6 BTU/BBL, (0005,38)). 799
AN ALL STEEL HOPPER CAR WITH A CAPACITY OF 70 T HAS A GROSS TO 899
TARE WEIGHT RATIO OF ABOUT 4/1 (0023,1136). IT IS ASSUMED THAT 999
THIS FIGURE HOLDS FOR 100 T CARS AND THAT THE FUEL CONSUMPTION 1099
PER TRAIN IS AS CITED ABOVE. FROM DATA IN (0021,31) THE ENERGY 1199
CONSUMPTION ASSUMES AN AVERAGE USAGE OF 3 LOCOMOTIVES PER 1299
TRAIN. 1399
THE AVERAGE HAULAGE DISTANCE IS 300 MI (1005,96). HENCE, FUEL 1499
CONSUMPTION IS 25,000 GAL PER ROUND TRIP OR 1.03E5 GAL/1.0E12 1599
BTU. THE EMISSION FACTORS ARE COMPUTED FROM (0002,3-7). 1699
WINDAGE LOSSES, ASSUMED TO BE AIRBORNE AS PARTICULATES, ARE 1799
ABOUT .04P OF THE TONNAGE HAULED (0002,7-4). SINCE THE LOSSES 1899
OCCUR MAINLY DURING HANDLING AT EITHER ENDPOINT, THEY ARE 1999
ESSENTIALLY INDEPENDENT OF THE HAULAGE DISTANCE. THUS, 16.4 2099
T OF COAL FINES ARE RELEASED AS PARTICULATES FOR EACH 2199
1.0E12 BTU HAULED. 2299
2399

NOTE: HAULAGE BY UNIT TRAIN ACCOUNTS FOR 22P OF THE TOTAL COAL 2499
MOVEMENT (1004,54). 2599

1006 199

THE AVERAGE CAPACITY OF A BARGE IS 25,000 T (1005,34), AND THE 299
AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 300 MI. THE EMISSION 399
IS CALCULATED FROM DATA ON MOTORSHIPS UNDERWAY IN (0002,3-11). 499
THE WINDAGE LOSSES, OCCURING MAINLY FROM HANDLING AT THE 599
ORIGIN AND TERMINAL POINTS, ARE ASSUMED TO BE .04P OF THE TOTAL 699
SHIPMENT AS IN THE CASE FOR UNIT TRAINS. THUS, 16.4 T OF COAL 799
FINES ARE EMITTED AS PARTICULATES (FOOTNOTE 1005). 899
999

NOTE TRANSPORT BY BARGE ACCOUNTS FOR 13P OF THE TOTAL COAL 1099
MOVEMENT (1004,53). 1199

1007 199

THE AVERAGE HAULAGE DISTANCE IS 300 MI (1005,96) AND FUEL CONSUMP- 299
TION IS AT A RATE OF .005 GAL/TM (FOOTNOTE 1005). ASSUMING 399
1000 T IS CARRIED PER TRIP AND ACCOUNTS FOR 20P OF THE TOTAL 499
TONNAGE OF ANY ONE SHIPMENT, A GROSS TO TARE WEIGHT RATIO OF 599
4/1, AND ONLY ONE WAY DIESEL FUEL CONSUMPTION ATTRIBUTED TO 699

COAL, 81,000 GAL OF DIESEL FUEL IS CONSUMED TO TRANSPORT 799
1.0E12 BTU COAL. THE EMISSIONS ARE COMPUTED FROM INFORMA- 899
TION ON DIESEL LOCOMOTIVES IN (0002,3-7). THE WINDAGE LOSSES 999
ARE ASSUMED TO BE APPROXIMATELY .08P OF THE TOTAL SHIPMENT. 1099
HENCE, ABOUT 32.8 T IS RELEASED TO THE ATMOSPHERE AS PARTI- 1199
CULATES. 1299
1399
NOTE - TRANSPORT BY MIXED TRAIN ACCOUNTS FOR 44 PC OF THE 1499
TOTAL COAL MOVEMENT (1004,53,54). 1599

1008 199

WHEN TRUCKS ARE UTILIZED IT IS USUALLY FOR SHORT HAULAGE DISTANCES 299
THAT AVERAGES ABOUT 10 MI (1013). ASSUMING AN AVERAGE TRUCK 399
CAPACITY OF 20 T, A GROSS TO NET WEIGHT RATIO OF 2.5/1, AND A 499
FUEL CONSUMPTION RATE OF 7 GAL/1000 TMI, 6600 GAL OF FUEL IS 599
CONSUMED/1.0E12 BTU. THE EMISSIONS FROM A DIESEL ENGINE ARE 699
GIVEN IN (0002,3-7). IT IS ASSUMED THAT .04P OF THE TOTAL 799
SHIPMENT IS LOST DUE TO WINDAGE. THE AMOUNT RELEASED AS PAR- 899
TICULATES IS, THEREFORE, 16.4 TONS (SEE ALSO FOOTNOTE 1005). 999
1099
NOTE HAULAGE BY TRUCK ACCOUNTS FOR 12P OF THE TOTAL COAL 1199
MOVEMENT (1004,53). 1299

1009 199

THE AVERAGE DEPTH OF OVERBURDEN OF COAL MINED IN 1965 WAS 48 FT 299
(1017). IN AREA SURFACE MINING ALL OF THE OVERBURDEN, EXCEPT 399
THAT WHICH IS REMOVED DURING THE BOX CUT, IS DEPOSITED IN 499
SPOIL BANKS IN THE EXCAVATED AREA. HENCE, THE SOLID WASTE IS 599
PRODUCED ONLY DURING THE INITIAL EXCAVATION. THE DENSITY OF 699
THE OVERBURDEN IS ABOUT 0.05 T/CF. ASSUMING THAT ON THE AVER- 799
AGE 5 AC (PIT SIZE OF ROUGHLY 100 FT BY 2000 FT, (1007)) ARE 899
EXCAVATED FOR THE BOX CUT AND 50 MMT OF COAL ARE CONSEQUENTLY 999
EXTRACTED, SOLID WASTE PRODUCTION OCCURS AT A RATE OF 0.0105 1099
T/T OF COAL OUT, OR 347 T/1.0E12 BTU IN. 1199

1010 199

THE PRODUCTION RATE FOR THE AUGERING OPERATION IS ASSUMED TO BE 299
655 T/SHIFT (1061,60,61, AND USING A 65P OPERATING FACTOR, 399
1061,51) AND FUEL CONSUMPTION AT 215 GAL/SHIFT. THUS, FOR THE 499
EXTRACTION OF 1.0E12 BTU EQUIVALENT T THE ENERGY CONSUMPTION 599
IS 1.87E9 BTU OR 8.63E8 BTU/1.0E12 BTU IN. 699

1011 199

THE OCCUPATIONAL HEALTH STATISTICS FOR THE PREPARATION PLANT 299
COULD NOT BE DISAGGREGATED FOR THE INDIVIDUAL PROCESSES 399
WITHIN THE PLANT NOR COULD A DISTINCTION BE MADE FOR THE 499
DIFFERENT TYPES OF PLANTS. THE DATA REFLECTS AN AVERAGE FOR 599
THE YEARS 1969 AND 1970 (1070,1210). 699

1012 199

CONVEYER SYSTEMS ARE EITHER COVERED OR OPERATED AT SUCH A SPEED 299
THAT DUSTING DOES NOT OCCUR TO ANY GREAT EXTENT (1011). WHERE 399
DUSTING DOES OCCUR, IT WILL BE CONFINED TO THE IMMEDIATE AREA 499
AND SHOULD PRESENT NO PROBLEM. THE PROPORTION TRANSPORTED BY 599
THIS METHOD IS VERY SMALL. THIS MODE OF TRANSPORT IS USUALLY 699
USED IN CONJUNCTION WITH ANOTHER MODE, E.G., TRAIN OR BARGE. 799

1013 199

THE DIESEL FUEL CONSUMPTION FOR A CONTOUR STRIPPING OPERATION IS 299
ESTIMATED TO BE 10600 GAL/1.0E12 BTU IN 399
(FOOTNOTE 1804). THE EMISSION FACTORS ARE OBTAINED FROM REF. 499
(0002,3-7) ASSUMING THE CHARACTERISTICS OF A DIESEL TRUCK 599
ENGINE. 699
SINCE MOST OF THE COAL PRODUCTION OCCURS IN AREAS WHERE 799
ADEQUATE MOISTURE IS AVAILABLE, FUGITIVE DUST IS NOT EXPECTED 899
TO BE A SERIOUS PROBLEM. 999

1014

EQUIPMENT USED IN UNDERGROUND MINES IS GENERALLY ELECTRICALLY POWERED AND THUS, EMISSIONS ARE NOT ASSOCIATED WITH THESE OPERATIONS.

1015

THE DIESEL FUEL CONSUMPTION FOR AN AUGERING OPERATION IS ESTIMATED TO BE 6220 GAL/1.0E12 BTU IN (FOOTNOTE 1010). THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7) ASSUMING THE CHARACTERISTICS OF A DIESEL TRUCK ENGINE.

1016

THE LAND USAGE BY DIESEL FRIEGHT TRUCKS IS 1.67E-6 AC/TMI (FOOTNOTE 7026). THUS, THE LAND IMPACT ATTRIBUTED TO THE HAULAGE OF COAL BY TRUCK IS 1.58 AC-YR/1.0E12 BTU (FOOTNOTE 1008).

1017

THE ONLY PIPELINE IN OPERATION IN THE UNITED STATES IS IN ARIZONA. THE TRANSPORT CAPACITY IS 4.8 MMT/YR AND SPANS A DISTANCE OF 273 MI (1015). ASSUMING A RIGHT-OF-WAY OF 62.5 FT, 2070 AC ARE OCCUPIED FOR THE PIPELINE. HENCE, 18.2 AC ARE IMPACTED FOR EACH 1.0E12 BTU. THERE ARE 4 PUMPING STATIONS EACH OCCUPYING APPROXIMATELY 50 AC, INCLUSIVE OF STATION HOUSE, ACCESS ROADWAYS AND STORAGE PONDS FOR WATER AND EMERGENCY SLURRY DUMP (1040,153/158). THUS AN ADDITIONAL 1.71 AC-YR/1.0E12 BTU OF LAND IS UTILIZED.

NOTE. THE RIGHT-OF-WAY IS THE AVERAGE VALUE FOR OIL PIPELINES (2002,14).

1018

IT IS ASSUMED THAT THE DRAINAGE FROM UNDERGROUND MINES IS THE SAME REGARDLESS OF THE METHOD UTILIZED. THIS IS NOT STRICTLY TRUE. SINCE THE RATE OF SUBSIDENCE FOR LONGWALL MINING IS GREATER, THE AMOUNT OF SEEPAGE (THROUGH FAULTS) INTO THE MINE WILL TEND TO BE LARGER THEREBY LEADING TO INCREASED DRAINAGE. BUT IT IS ALSO TRUE THAT THE DRAINAGE BETWEEN MINES, IRRESPECTIVE OF THE MINING TECHNIQUE EMPLOYED, WILL VARY TO A DEGREE THAT MAY EVEN BE GREATER.

THE DRAINAGE FROM ACTIVE UNDERGROUND MINES OCCURS AT A RATE OF 1177 T OF ACIDITY PER DAY (1039,5,8) OR 0.0015 T/T OF COAL EXTRACTED (COAL PRODUCTION FROM (0001)) AND THE SULFATE LOADING IS ABOUT TWICE AS MUCH AS THE ACID LOADING (1039).

THE CHEMICAL COMPOSITION OF THE DRAINAGE IS ESTIMATED FROM DATA FOR THE MONONGAHELA RIVER BASIN (1039,133/139 ALSO FOOTNOTE 1020). THE EFFLUENT DATA WERE ADJUSTED TO REFLECT ONLY CONTRIBUTIONS FROM ACTIVE UNDERGROUND MINING BY USE OF THE DATA IN (1039,6). THE EFFLUENT BREAKDOWN IS AS FOLLOWS:

	$T/10^3$ TON COAL	T/1.0E12 BTU IN ROOM & PILLAR	LONGWALL
HARDNESS	12.2	242.0	378.0
FE	0.214	4.3	6.6
MN	0.0907	1.8	2.8
AL	0.0269	0.5	0.9
SO_4		59.6	93.0
TOTAL		308.2	481.3
ACIDITY (AS $CACO_3$)		29.8	46.5

THE DIFFERENCE IN QUANTITIES FOR THE DIFFERENT MINING TECHNIQUES IS DUE TO THE DIFFERENCE IN REGIONS OF PRODUCTION AND

THE PRIMARY EFFICIENCIES. ACID DRAINAGE FROM DEEP MINES IS A PROBLEM MAINLY IN THE APPALACHIAN REGION. IN THE CENTRAL REGION (MIDWEST) THIS IS NOT A SERIOUS PROBLEM (1105). MOST OF THE MINES ARE LOCATED BELOW DRAINAGE AND IN SOME CASES THE OVERBURDEN IS ALKALINE. THE OVERBURDEN IN MINES LOCATED IN THE WEST IS OF HIGH ALKALINE CONTENT, THUS THE DRAINAGE TENDS TO BE BASIC. THE EFFLUENT FROM THESE MINES ARE MINIMAL (FOOTNOTE 1020, VERY LITTLE UNDERGROUND MINING IS DONE IN THE WEST).

HENCE, IT HAS BEEN ASSUMED THAT ACID DRAINAGE OCCURS ONLY IN THE APPALACHIAN STATES (85P FOR ROOM ANDPILLAR MINES, AND 89P FOR LONGWALL MINES).

THE SEDIMENT YIELD FROM THE REFUSE PILE OCCURS AT A RATE OF 2.54 T/AC-YR-IN OF RUNOFF (COMPUTED FROM INFORMATION IN (1020)). THUS, ASSUMING AN AVERAGE RUNOFF OF 15 IN, THE SEDIMENT LOAD IS 2.04E-2 T/1.0E12 BTU IN (FOOTNOTE 1022 FOR LAND IMPACTED BY THE SOLID WASTE) FOR ROOM AND PILLAR MINING AND 3.05E-2 T/1.0E12 BTU IN (FOOTNOTE 1036) FOR LONGWALL MINING.

1019

PRODUCTION FROM AUGER MINES IS PREDOMINANTLY (99P) FROM THE APPALACHIAN REGION. THUS, DATA ON MINES IN APPALACHIA ARE UTILIZED TO DETERMINE THE EFFLUENT LOADING.

THE DRAINAGE FROM THE MINE IS ASSUMED TO BE THE SAME AS FOR CONTOUR MINES (FOOTNOTE 1041).

THE SEDIMENT YIELD IS 2.54 T/AC-YR-IN. THUS FOR A RUNOFF OF 15 IN, THE SEDIMENT YIELD IS 674 T/1.0E12 BTU IN (FOOTNOTE 1026, LAND USE BY SPOIL PILE).

1020

OF THE TOTAL PRODUCTION OF COAL FROM SURFACE MINES, 92P WAS MINED IN AREAS WHERE THE POTENTIAL FOR ACID DRAINAGE EXISTS. THIS PROPORTION IS ASSUMED TO HOLD FOR AREA STRIP MINING WHICH IS THE ASSUMED METHOD EMPLOYED ON SLOPES OF LESS THAN 15 DEGREES.

DRAINAGE FROM ACTIVE MINES IN APPALACHIA IS THE ASSUMED MODEL FOR ACID DRAINAGE. FROM SURFACE MINES ACID WATERS ENTER THE STREAMS AT A RATE OF 62.0 T/DAY (1039,5,8), OR 2.0E-4 T/T OF COAL EXTRACTED (COAL PRODUCTION FROM (0001)) AND THE SULFATE LOADING IS ABOUT TWICE THE ACID LOADING (1039).

THE CHEMICAL COMPOSITION OF THE DRAINAGE FROM THE ACTIVE MINES IS ESTIMATED FROM DATA ON THE MONONGAHELA RIVER BASIN (1039, 133/139). THE DATA FROM 10 GAGING STATIONS WERE USED IN THE ESTIMATION AND THE COAL PRODUCTION FIGURES WERE OBTAINED FROM REFERENCE (0001). THE EFFLUENT DATA IN TON/TON COAL WERE ADJUSTED TO REFLECT ONLY CONTRIBUTIONS FROM ACTIVE SURFACE MINING BY THE DATA IN (1039,6). IN DETERMINING THE HARDNESS A CONCENTRATION OF 100 MG/L WAS ASSUMED TO OCCUR NATURALLY, WHILE THE METALLIC CONSTITUENTS ARE ASSUMED TO ORIGINATE FROM THE MINES. THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	$T/10^3$ T COAL STRIPPED	T/1.0E12 BTU IN
HARDNESS	0.901	27.5
FE	0.0158	0.5
MN	0.00663	0.2
AL	0.00198	0.1
SO_4		12.2
TOTAL		40.5
ACIDITY (AS $CACO_3$)		6.11

FTN. 1021

IT HAS BEEN ASSUMED THAT THE PROPORTION OF THE DRAINAGE ASSOCIATED WITH SURFACE MINES IS THE SAME AS THAT FOR THE ACIDIC DRAINAGE IN THE BASIN.

ALTHOUGH THE MONONGAHELA BASIN IS USED AS A MODEL, IT SHOULD BE NOTED THAT THE COMPOSITION AND THE QUANTITY OF THE DRAINAGE VARIES BETWEEN MINES.

THE SEDIMENT YIELD OCCURS AT A RATE OF 2.54 T/YR-AC-IN OF RUNOFF (1020). THUS, ASSUMING AN AVERAGE RUNOFF OF 15 IN, 5.07 T OF SILT IS CONTRIBUTED TO THE NATURAL DRAINAGE FOR EACH 1.0E12 BTU IN ((FOOTNOTE 1001), LAND USE BY SOLID WASTE PILE).

OF THE COAL MINED IN AREAS WHERE THE DRAINAGE IS NOT ACIDIC, 62P WAS MINED IN THE NORTHERN GREAT PLAINS PROVINCE. HENCE, IT IS ASSUMED THAT THE WATER LEAVING THE MINES IS SIMILAR TO THAT OF MINES IN THE POWDER RIVER BASIN. ABOUT 12 GAL OF WATER IS YIELDED FOR EACH TON OF COAL EXTRACTED (1021,1022) AND THE GROUNDWATER IN THE AREA CONTAINS (1023)

	K AND NA	MG	CA	FE	SO4
PPM	210	127	92	25.4	413

THE DRAINAGE FROM THE MINE ALSO CONTAINS ABOUT 1600 PPM OF COAL FINES AS SUSPENDED SOLIDS (1022). THUS, THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	1.0E-3 T/1.0E12 BTU IN
MG	16.8
CA	12.2
FE	3.4
SO_4	54.8
K AND NA	27.6
TOTAL	114.8
SUSPENDED SOLIDS (COAL FINES)	212.0

1021

SOLID WASTE PRODUCTION AT UNDERGROUND MINES IS IN GENERAL RELATED TO THE OPENING OF THE MINE. ASSUMING AN AVERAGE MINE DEPTH OF 600 FT (WHICH IS THE AVERAGE FOR ILLINOIS (1016)) AND A SHAFT OPENING OF 100 SF, 3000 T OF EARTH IS REMOVED TO SINK THE SHAFT. FURTHER ASSUMING AN AVERAGE PRODUCTION OF 50 MMT PER MINE, THE PRODUCTION OF SOLID WASTE OCCURS AT A RATE OF 60E-6 T/T OF COAL MINED. HENCE, 2.46 T OF SOLID WASTE IS PRODUCED PER 1.0E12 BTU EQUIVALENT TONS EXTRACTED. BASED ON A PRIMARY EFFICIENCY OF .85 FOR LONGWALL MINING AND .57 FOR ROOM AND PILLAR THIS IS EQUIVALENT TO 2.09 AND 1.40 TONS RESPECTIVELY PER 1.0E12 BTU IN.

1022

IN A PILE 30 FT IN HEIGHT, 4.59E-2 AC OF LAND IS OCCUPIED BY THE REFUSE PILE (FOOTNOTE 1021, SOLID WASTE PRODUCTION). THE AVERAGE ANNUAL PRODUCTION FROM SIZABLE UNDERGROUND MINES IS APPROXIMATELY 2 MMT (1005,90). HENCE, THE LAND (FIXED) UTILIZED FOR STORAGE IS 5.36E-4 AC-YR/1.0E12 BTU IN.

THE AVERAGE THICKNESS OF SEAMS MINED UNDERGROUND IN 1965 WAS 5.3 FT (1017,5), WHICH WAS ALSO THE AVERAGE THICKNESS FOR THE PERIOD FROM 1945-1965. ON THIS BASIS, 4.38 AC OF LAND IS UNDERMINED FOR EVERY 1.0E12 BTU IN.

OF THE ACREAGE UNDERMINED APPROXIMATELY 25P WILL SUBSIDE (1019). THIS SUBSIDENCE RATE IS ACTUALLY FOR ALL UNDERGROUND COAL MINES, BUT SINCE THE ROOM AND PILLAR TECHNIQUE HAS BEEN PREDOMINANT IN THE US, IT IS ASSUMED THAT THIS FIGURE CHARACTERIZES THE SUBSIDENCE FOR ROOM & PILLAR MINING. EVENTUALLY ALL OF THE AREA UNDERMINED MAY SUBSIDE, BUT THE TIME SCALE IS IN EXCESS OF A CENTURY. THE 25P SUBSIDENCE RATE IS DERIVED FROM HISTORICAL OBSERVATIONS.

SUBSIDENCE AFFECTS A SURFACE AREA GREATER THAN THE AREA UNDERMINED. THE WIDTH ON THE PERIMETER THAT IS AFFECTED BY SUBSIDENCE IS DETERMINED FROM

$$R=H \tan X$$

WHERE, R=WIDTH OF THE PERIMETER AREA AFFECTED, H=DEPTH OF MINE, AND X=ANGLE OF DRAW (ANGLE BETWEEN A VERTICAL LINE, AND A LINE CONNECTING THE FACE AND THE LIMIT OF SUBSIDENCE). THE ANGLE OF DRAW HAS BEEN CONSISTENTLY OBSERVED IN EUROPEAN COAL FIELDS TO FALL BETWEEN 35-39 DEGREES (1027,232,233). THUS, FOR AN ANGLE OF DRAW OF 37 DEGREES AND A MINE DEPTH OF 600 FT, THE WIDTH OF THE AFFECTED PERIMETER AREA IS 452 FT.

OF THE UNDERMINED AREA 1.10 AC SUBSIDES. ASSUMING A SQUARE AREA, THE SIDES ARE 219 FT IN LENGTH. HENCE, THE ADDITIONAL LAND AFFECTED HAS AN AREA OF 9.09 AC. THEREFORE, THE TOTAL AREA AFFECTED BY SUBSIDENCE ENCOMPASSES 10.2 AC.

THE AVERAGE LIFE OF A SIZABLE UNDERGROUND MINING OPERATION IS ABOUT 25 YR. THUS, THE TIME AVERAGE LAND IMPACT IS 127 AC-YR PER 1.0E12 BTU IN.

1023

THE OCCUPATIONAL HEALTH STATISTICS FOR ALL METHODS OF MINING REFLECT AVERAGES FOR THE YEARS 1969, 1970 AND 1971 (1070,1071, 1210). THE DATA COULD NOT BE DISAGGREGATED FOR THE DIFFERENT UNDERGROUND AND SURFACE MINING TECHNIQUES.

1024

DISCHARGE OF THE RESIDUAL WATER FROM THE COAL SLURRY IS NOT ALLOWED. WASTEWATER AT THE POWER PLANT CONTAINS 25 PPM OF SOLIDS. THE WATER IS USED FOR COOLING TOWER MAKEUP, ASH HANDLING OR PLANT USE AND THE REMAINDER IS EVAPORATED IN PONDS (1024).

1025

THE EMISSIONS FROM THE THERMAL DRIERS ARE COAL FINES IN THE FORM OF PARTICULATES. THUS, THE PARTICULTES COLLECTED BY THE CYCLONES ARE USUALLY FED BACK TO THE DRIERS FOR COMBUSTION. THEREFORE, NO SOLID WASTE IS PRODUCED.

1026

THE AVERAGE THICKNESS OF COAL SEAMS AUGER MINED IN 1965 WAS 4.2 FT (1017,7). THUS FOR EVERY 1.0E12 BTU EQUIVALENT TON 5.53 AC OF LAND ARE UNDERMINED. UNDER THE ASSUMPTION THAT THE RATIO OF LAND SUBSIDED TO LAND UNDERMINED IS THE SAME AS FOR ROOM AND PILLAR UNDERGROUND MINES (FOOTNOTE 1022), 1.38 AC OF SURFACE AREA SUBSIDES. BECAUSE OF THE SHALLOW OVERBURDEN DEPTH, THE PERIMETER EFFECT IS NEGLIGIBLE. FOR AN AUGER LENGTH OF 150 FT, ABOUT 1607 FT OF WORKING BENCH ARE CREATED FOR EACH 1.0E12 BTU IN. THUS FOR A BENCH WIDTH OF 35 FT (1052), 1.29 AC/1.0E12 BTU IN OF LAND ARE DISTURBED. IT IS ASSUMED THAT THE EXCAVATED OVERBURDEN IS DUMPED ON THE OUTSLOPES. THUS IN A PILE AVERAGING 15 FT IN HEIGHT THE SPOIL BANK EXTENDS 34.3 FT DOWNSLOPE FROM THE OUTCROP COVERING AN AREA OF 1.27 AC/ 1.0E12 BTU IN (FOOTNOTE 1070 SOLID WASTE PRODUCTION). CALCULATIONS FROM DATA COLLECTED IN EASTERN KENTUCKY (1029,1030, 1031,1032,1033,1034) INDICATE THAT LANDS AFFECTED BY LANDSLIDES AMOUNT TO 11.4 PC OF THE OUTSLOPE COVERED BY THE SPOILS. HENCE, AN ADDITIONAL LAND ACREAGE OF .145 AC/1.0E12 BTU IN IS DAMAGED. THE TOTAL LAND DAMAGED DURING AUGERING AMOUNTS TO 4.09 AC/1.0E12 BTU IN. THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS 51.1 AC-YR/1.0E12 BTU IN.

1027

AVERAGE MILES OF ROAD OPERATED IN 1970 WAS 209,401 MI AND OF THE TOTAL TONNAGE HAULED IN THE SAME YEAR, 27P WAS COAL (0011, 559). THUS, ASSUMING A RIGHT-OF-WAY OF 50 FT (6 AC/MI), THE LAND IMPACT ASSOCIATED WITH THE TRANSPORT OF COAL IS 339,230 AC. OF THE TOTAL TONNAGE OF COAL TRANSPORTED, 1.0E12 BTU EQUIVALENT TONS ACCOUNTS FOR 0.01P. THE LAND IMPACT IS THEREFORE 33.9 AC.

1028

ASSUMING PARTICULATE REMOVAL EFFICIENCY OF 87P FOR THE QUENCHING PROCESS (1025) AND 95PC FOR THE COKING CYCLE, THE EMISSIONS ARE AS FOLLOWS (0002,7-4) IN T/1.0E12 BTU (SEE FOOTNOTE 1047 FOR COAL HEATING VALUE).

	PARTICULATES	SOX	CO	HC	NOX	NH3
BY-PRODUCT COKING: (HORIZONTAL CHAMBER)						
UNLOADING	7.3					
CHARGING	28.9	0.39	11.7	48.9	0.584	0.39
COKING CYCLE	0.10		11.7	29.3	0.195	1.17
DISCHARGING	11.7		1.3	3.9		1.95
QUENCHING	2.3					
UNDERFIRING		195.0				
TOTALS	50.3	195.4	24.7	82.1	0.779	3.51
BEEHIVE	3900		19.5	156.0		39.0

1029

THE EFFICIENCIES FOR PARTICULATE REMOVAL ARE GIVEN IN FOOTNOTE 1028. THUS, THE SOLID WASTE PRODUCED IS AS FOLLOWS

	T/1.0E12 BTU
BY-PRODUCT COKING (HORIZONTAL CHAMBER)	17.1

1030

ASSUMING A DENSITY OF 0.03 T/CF FOR THE SOLID WASTE PRODUCED FROM COKING AND A REFUSE PILE HEIGHT OF 30 FT, 0.00043 AC WILL BE UTILIZED FOR STORAGE FOR EACH 1.0E12 BTU EQUIVALENT TONS OF COAL PROCESSED FOR THE HORIZONTAL CHAMBER. THE AVERAGE ECONOMIC LIFE OF PRODUCTION FACILITIES IN THE STEEL INDUSTRY IS ABOUT 26 YR (0022). THUS, ASSUMING THE SAME LIFE SPAN FOR THE COKE PLANT, THE TIME AVERAGED LAND IMPACTS ARE 0.00566 AC-YR/ 1.0E12 BTU.

AT BETHLEHEM STEEL IN BALTIMORE, APPROXIMATELY 2.6 MMT OF COAL ARE PROCESSED ANNUALLY AND THE LAND AREA UTILIZED FOR COKE PRODUCTION AND STORAGE IS ABOUT 90 AC. THUS, 1.35 AC -YR OF LAND IS ATTRIBUTABLE TO THE PROCESSING OF 1.0E12 BTU.

1031

STORAGE OF 1.0E12 BTU EQUIVALENT T OF COAL ABOVE GROUND IN A PILE 30 FT HIGH, REQUIRES THE USE OF 0.762 AC OF LAND. IT IS ASSUMED THAT UNDERGROUND STORAGE WILL ALSO REQUIRE THE SAME AMOUNT OF LAND.

1032

GENERALLY, SILOS HAVE A DIAMETER OF 70 FT AND ARE ABOUT 150 FT IN HEIGHT. THE STORAGE CAPACITY IS APPROXIMATELY 11,000 T (1006). THUS, 4 SILOS ARE REQUIRED FOR STORING 1.0E12 BTU EQUIVALENT T. THE LAND UTILIZED BY THE SILOS IS THEREFORE 0.354 AC.

1033

FOR THE PERIOD 1969 TO 1970, SHIPMENT OF COAL ACCOUNTED FOR 27P OF THE TOTAL TONS OF FREIGHT SHIPPED BY RAIL (0011,559). OF THE TOTAL TONNAGE OF COAL TRANSPORTED, 1.0E12 BTU EQUIVALENT T ACCOUNTS FOR 0.01P (TOTAL COAL, 330 MMT). DURING THE SAME PERIOD AN AVERAGE OF 2255 FATALITIES OCCURED AND 21,666 PERSONS WERE INJURED IN RAIL ACCIDENTS (0006). THESE FIGURES ARE FOR THOSE OTHER THAN PASSENGER FATALITIES AND INJURIES, AND INCLUDES ALL ACCIDENTS. INJURIES TO EMPLOYEES ON DUTY AVERAGED 16,250 PERSONS AND 93 MAN-DAYS WERE LOST PER INJURY (0006). HENCE, FOR EVERY 1.0E12 BTU EQUIVALENT T HAULED THERE ARE 0.0610 FATAL INJURIES, 0.585 NONFATAL INJURIES, AND 59.5 MAN-DAYS LOST.

1034

THE EFFLUENTS FROM A BYPRODUCT COKING OPERATION ARE PRESENTED IN REFERENCE (1037,16) IN TERMS OF TONS OF DRY COAL PROCESSED. THE CONVERSION TO TONS OF COAL AS RECEIVED IS DONE FOR A MOISTURE CONTENT OF 5P. THE MOISTURE CONTENT IS LIMITED TO A MAXIMUM OF ABOUT 7P TO PREVENT DAMAGE TO THE BRICKWORK (1038). THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	T/1.0E12 BTU IN
CYANIDE	5.84
AMMONIA	6.49
TOTAL	12.33
BOD5	59.4
PHENOLS	10.2

THE HEATING VALUE OF COAL RECEIVED AT COKING PLANTS IS ASSUMED TO BE 13000 BTU/LB (FOOTNOTE 1047). VERY LITTLE THERMAL DISCHARGES ARE ASSOCIATED WITH SLOT OVENS (1044) AND NO DATA HAS BEEN FOUND ON SUSPENDED SOLIDS. BOTH ARE OF COURSE DEPENDENT ON FACILITIES UTILIZED.

1035

IT IS ASSUMED THAT 0.006P OF THE FEED TO THE ROUGH CLEANING UNIT IS REMOVED AS TRAMP IRON. HENCE, 2.46 T OF TRAMP IRON IS COLLECTED FOR EVERY 1.0E12 BTU EQUIVALENT TONS PROCESSED. THE PERCENTAGE OF TRAMP IRON IS ESTIMATED FROM INFORMATION IN REF. (1059,6-31) ASSUMING THAT THE LARGE PLANT PROCESSED 1000 T/HR.

1036

SINCE IN LONGWALL MINING THE ROOF IS COLLAPSED AS MINING PROGRESSES, IT IS ASSUMED THAT SUBSIDENCE OCCURS OVER THE ENTIRE AREA UNDERMINED. THUS, 4.38 AC OF LAND SUBSIDES FOR EACH 1.0E12 BTU EQUIVALENT T (SEAM THICKNESS IS 5.3 FT, FOOTNOTE 1022). THE WIDTH OF THE AREA OF INFLUENCE IS 452 FT (FOOTNOTE 1022). THEREFORE, THE ADDITIONAL LAND AFFECTED BY SUBSIDENCE ENCOMPASSES 18.1 AC. THE TOTAL LAND AFFECTED IS 22.5 AC/1.0E12 BTU, AND THE TIME AVERAGED (OVER THE 25 YR MINE LIFE) LAND IMPACT IS 280 AC-YR/1.0E12 BTU IN.
THE REFUSE PILE OCCUPIES AN AREA OF 8.00E-4 AC-YR/1.0E12 BTU IN (FOOTNOTE 1022).

1037

FOR A COAL SEAM THICKNESS OF 3.8 FT (1001) AND A COAL DENSITY OF 81 LB/CF, 6.12 AC OF LAND IS OVERTURNED PER 1.0E12 BTU IN.

ON SLOPES GREATER THAN 15 DEGREES, TECHNIQUES OF CONTOUR STRIPPING ARE EMPLOYED. IT IS ASSUMED THAT THE CONVENTIONAL CONTOUR MINING IS USED. EXCEPT FOR THE MATERIAL USED TO BACKFILL THE BENCH, ALL OF THE OVERBURDEN IS DEPOSITED ON THE OUTSLOPE AND ASSUMED TO REST AT THE ANGLE OF REPOSE (ABOUT 37 DEGREES). IT IS ALSO ASSUMED THAT A 15 FT RIM OF BLOSSOM COAL IS LEFT IN PLACE. THE MEAN SLOPE ANGLE AND THE BENCH WIDTH ARE ASSUMED TO BE 20 DEGREES (1028,3-6) AND 150 FT RESPECTIVELY. HENCE, A HIGHWALL OF 60 FT IS CREATED, AND FOR 1.0E12 BTU IN OF COAL 1776 FT OF HIGHWALL (BENCH LENGTH) ARE GENERATED.
THE SPOIL BANK IS ASSUMED TO HAVE A MEAN HEIGHT OF 45 FT. THUS, THE PILE REACHES 959 FT DOWNSLOPE FROM THE OUTCROP AND ENCOMPASSES AN AREA OF 3.91 AC/1.0E12 BTU IN (FOOTNOTE 1038, SOLID WASTE PRODUCTION).
THE DRAINAGE DITCH ABOVE THE HIGHWALL IS ASSUMED TO AFFECT 50 FT UPSLOPE. HENCE, 2.04 AC/1.0E12 BTU IN OF LAND IS UTILIZED. CALCULATIONS FROM DATA COLLECTED IN EASTERN KENTUCKY (1029, 1030,1031,1032,1033,1034) INDICATES THAT LAND AFFECTED BY LANDSLIDES AMOUNTS TO 11.4P OF THE OUTSLOPE AREA COVERED BY THE SPOILS. THUS, AN ADDITIONAL LAND ACREAGE OF 0.446 AC/1.0E12 BTU IN IS DAMAGED. IT IS RECOGNIZED THAT THIS WILL NOT BE THE CASE FOR ALL MINES, IN THAT MORE STABLE SLOPE ANGLES FOR THE SPOIL BANKS ARE REQUIRED IN SOME STATES. OBSERVATIONS (1035) INDICATE THAT THE OCCURRENCE OF LANDSLIDES IS SIGNIFICANTLY REDUCED WHEN THE OUTSLOPES ARE STABILIZED. (NO STABILIZATION IS INCLUDED IN THE ABOVE COMPUTATIONS).
THE TOTAL LAND USAGE (EXCLUSIVE OF HAULAGE ROADS) IS 12.5 AC PER 1.0E12 BTU IN. THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS THEREFORE 156 AC-YR/1.0E12 BTU IN.
ALTHOUGH RECLAMATION PRACTICES ARE ESPOUSED, NOT ALL APPALACHIAN STATES HAVE MANDATORY VEGETAL SURVIVAL RATE REQUIREMENTS (1028) NOR ARE THERE STIPULATIONS FOR RECLAMATION OF TOP SOIL. THUS, EXCEPT FOR COVERING THE EXPOSED SEAM AND THE PIT FLOOR, NO RECLAMATION HAS BEEN ASSUMED.

1038

FOR A SLOPE ANGLE OF 20 DEGREES, A BENCH WIDTH OF 150 FT AND A 15 FT RIM OF BLOSSOM COAL (FOOTNOTE 1037), 4.37E05 TON OF EARTH ARE MOVED/1.0E12 BTU IN.

AS A REQUIREMENT OF BACKFILLING, IT IS ASSUMED THAT 4 FT OF MATERIAL, ABOVE THE HEIGHT OF THE COAL SEAM, MUST BE REPLACED. THUS, FOR A 3.8 FT SEAM THICKNESS (1001), 5.33E04 TON/1.0E12 BTU IN OF SPOILS ARE REPLACED IN BACKFILLING THE BENCH. THE SOLID WASTE PRODUCTION IS THEREFORE 3.83E05 T PER 1.0E12 BTU IN.

1039

THE OCCUPATIONAL HEALTH STATISTICS FOR HAULAGE OF COAL BETWEEN MINE AND TIPPLE REFLECT AN AVERAGE FOR THE YEARS 1969 AND 1970. (1070,1210). THE DATA INCLUDES THE FIGURES FOR ALL METHODS OF HAULAGE.

1040

A TYPICAL BEEHIVE OVEN IS ABOUT 12 FT IN DIAMETER AND WILL HANDLE AN AVERAGE CHARGE OF 7.5 T (0022,35). THE COKING TIME PER CHARGE IS APPROXIMATELY 60 HR. THUS, ON THE BASIS OF 5 DAY WK, EACH OVEN IS CAPABLE OF PROCESSING 780 T OF COAL/YR. TO PROCESS 1.0E12 BTU EQUIVALENT T OF COAL 50 OVENS ARE REQUIRED. THESE OVENS ARE USUALLY BUILT IN BATTERIES WHICH FOLLOW THE CONTOUR OF THE MOUNTAIN WHERE THEY ARE LOCATED. ALLOWING 20 FT OF WORKING AREA, A TERRACE 32 FT IN WIDTH AND 600 FT LONG IS REQUIRED. HENCE, 0.441 AC OF LAND IS UTILIZED.

SINCE THE BEEHIVE OVENS ARE USUALLY ASSOCIATED WITH A SPECIFIC MINE, IT IS ASSUMED THAT ABOUT A MILE OF TRACK IS REQUIRED TO TRANSPORT THE COAL. THE COAL IS USUALLY CHARGED TO THE OVENS FROM ABOVE, DIRECTLY FROM THE MINE CARS. ASSUMING A RIGHT-OF-WAY OF 20 FT, 2.42 AC OF LAND ARE OCCUPIED BY THE TRACK.

IN 1971, 6 PLANTS WERE IN OPERATION AND PROCESSED 1.29 MMT OF COAL (1036,5,6). ASSUMING EACH PLANT PROCESSED AN EQUAL SHARE, 0.215 MMT, THEN 1.0E12 BTU EQUIVALENT T ACCOUNTS FOR 19P OF THE PRODUCTION FOR ANY OF THE PLANTS. THEREFORE, 0.459 AC OF THE LAND OCCUPIED BY THE TRACK IS ATTRIBUTED TO THE PROCESSING OF 1.0E12 BTU EQUIVALENT T.

THE TOTAL LAND USAGE IS 0.900 AC-YR/1.0E12 BTU.

1041

MOST OF THE CONTOUR MINING OCCURS IN THE APPALACHIAN REGION. THUS, DATA FROM APPALACHIA IS USED IN THE DETERMINATION OF THE EFFLUENTS.

THE COMPOSITION OF THE DRAINAGE FROM ACTIVE CONTOUR MINES IN APPALACHIA IS AS FOLLOWS (FOOTNOTE 1020)

	T/1.0E12 BTU IN
HARDNESS	29.6
FE	0.5
MN	0.2
AL	0.1
SO4	13.1
TOTAL	43.5
ACIDITY	6.56

THE SEDIMENT YIELD OCCURS AT A RATE OF 2.54 T/YR-AC-IN OF RUNOFF (1020) AND IS ASSUMED TO ORIGINATE FROM ALL THE SPOILED AREA. THE RUNOFF IS ASSUMED TO BE 15 IN AND THE LAND AREA IS 54.5 AC-YR/1.0E12 BTU IN (FOOTNOTE 1037). HENCE, 2076 T OF SILT IS YIELDED PER 1.0E12 BTU IN.

1042

THE RAILS ARE MAINLY USED WITH UNDERGROUND MINES AND ARE EITHER ELECTRIC OR DIESEL ELECTRIC POWERED. THUS, THE EMISSIONS ARE EXPECTED TO BE MINIMAL.

SINCE THE TIPPLE IS USUALLY LOCATED IN THE PROXIMITY OF THE MINE MOUTH AND THE TRACKS ARE RELATIVELY NARROW, VERY LITTLE LAND WILL BE UTILIZED BY THE RAIL.

1043

IN AN EASTERN KENTUCKY STUDY,THE SEDIMENT YIELD FROM A COAL HAUL ROAD WAS DETERMINED TO BE 90 T/AC-YR (1020,C32). BECAUSE OF THE CONDITIONS, THE YIELD WAS EXCEPTIONALLY HIGH. FOR THE PRESENT COMPUTATION IT IS ASSUMED THAT THE SEDIMENT YIELD AVERAGES TO 35 T/AC-YR. THUS, 24.9 T/1.0E12 BTU OF SEDIMENT IS YIELDED (ACREAGE OF HAULAGE ROAD, FOOTNOTE 1004).

1044

IN 1971 THE RAILROAD FREIGHT CHARGE WAS $3.70/T (1004,7). ASSUMING THIS FIGURE FOR SHIPMENT BY MIXED TRAIN,THE FREIGHT RATE IS $154,000/1.0E12 BTU.

1045

FREIGHT CHARGES FOR SHIPMENT BY UNIT TRAIN (IN 1969) AVERAGED ABOUT $0.0061/TMI (1006,10).

ICC IMPOSED AN 8P AND 6P FREIGHT RATE INCREASE IN 1970 AND 1971, RESPECTIVELY. ASSUMING THAT UNIT TRAIN CHARGES INCREASED SIMILARLY THE FREIGHT RATE FOR A 300 MI TRIP (FOOTNOTE 1005) IS ABOUT $2.04/T OR $84,900/1.0E12 BTU.
THE FREIGHT CHARGES DO NOT APPEAR TO BE SENSITIVE TO THE OWNERSHIP OF THE CARS (1006,10).

1046

THE COST INVOLVED IN TRANSPORTATION FOR A 2 MMT/YR STRIP MINE HAS BEEN ESTIMATED FROM DATA IN REF.(1041,7/26) AND THE BREAKDOWN IS AS FOLLOWS

CAPITAL INVESTMENTS	1972 $		
ROAD GRADER (2)	132,700		
TRUCKS (5-100 T)	967,800		
WATER TRUCK (1)	22,100		
TOTAL	1,122,600		
OPERATING EXPENSE		$/1.0E12 BTU	
LABOR	158,590		
OPERATING SUPPLIES	158,990		
TOTAL	317,580	6510	
FIXED COST (10PC OF CAPITAL INVESTMENT)	112,260	2300	

INCLUDED IN LABOR IS THE COST FOR 2 GRADER OPERATORS AND 10 TRUCK DRIVERS EACH AT $40.90/DAY AND 4 MECHANICS EACH AT $42.50/DAY (WAGE RATES FROM REF. (1042,43/44)).ALL OTHER COST FIGURES HAVE BEEN ADJUSTED FROM 1969 TO 1972 BY A FACTOR OF 10.6P (WHOLESALE INDUSTRIAL PRICE INDEX IN REF. (0011,342)).

1047

IN 1971 THE AVERAGE VALUE OF COAL RECEIVED AT OVEN-COKE PLANTS WAS $14/T AND THE AVERAGE VALUE OF RECEIPTS FOR OVEN COKE WAS $37.41/T (1036,13,11). ON THE AVERAGE 1.45 T OF COAL WAS UTILIZED TO PRODUCE A T OF COKE (1036,13). THUS, THE COST OF PRODUCTION AMOUNTS TO $11.80/T OF COAL PROCESSED.

ASSUMING AN INPUT CALORIC VALUE OF 12,180 BTU/LB (FOOTNOTE 1000) TO THE METALLURGICAL PREPARATION PLANT, THE HEATING VALUE OF THE PRODUCT, WHICH IS THE COAL RECEIVED AT COKE PLANTS, IS 13000 BTU/LB (WEIGHTED AVERAGE OF THE PRODUCT FROM EACH OF THE CLEANING PROCESSES, FOOTNOTES 1805 AND 1813). HENCE, THE PRODUCTION COST OF OVEN COKE IS $462,000/1.0E12 BTU IN.

1048

IN 1971 THE AVERAGE VALUE OF COAL RECEIVED AT BEEHIVE-COKE PLANTS WAS $8.54/T AND THE AVERAGE VALUE OF RECEIPTS FOR BEEHIVE COKE WAS $21.45/T (1036,13,11). ON THE AVERAGE 1.67 T OF COAL WAS UTILIZED TO PRODUCE A T OF COKE. THUS, PRODUCTION COST AMOUNTS TO $4.30/T OF COAL PROCESSED OR $168,000/1.0E12 BTU.

1049

THE AVERAGE LENGTH OF HAULAGE CONVEYORS IS 2121 FT (1004,25). THE ECONOMIC ANALYSIS IS AS FOLLOWS (1043,589/609)

CAPITAL EXPENDITURE	1972 $
BELT	61,100
MACHINERY & STRUCTURES	49,600
DRIVES & ELECT EQUIPT	
200 HP MOTOR	42,500
150 HP MOTOR	26,300
TOTAL	179,500
ERECTION & INSTALLATION (25P)	44,900
TOTAL CAPITAL	224,400

OPERATING EXPENSES	1972 $/YR	$/1.0E12 BTU
BELT REPLACEMENT (SINKING FUND RETURNING FULL VALUE AT 4P AT END OF 8 YRS)	6,700	
REPAIR & MAINTAINANCE	5,500	
POWER ($0.015/KWH)	15,400	
LABOR	38,300	
	65,900	1351
FIXED COST (10P OF CAPITAL EXPENSE)	22,440	460

THE MINE PRODUCTION IS 2 MMT/YR OPERATING AT 240 DAY/YR WITH 2-8 HR SHIFTS/DAY. THE OPERATION REQUIRES A BELT OPERATOR AND A LABORER PER SHIFT AND THE WAGE RATES ARE OBTAINED FROM REF. (1042,43). THE COST OF THE EQUIPMENT IS ESCALATED FROM 1968 TO 1972 BY 14.8P (0011,342).

1050

THE DISCHARGE PER TON OF COKE PROCESSED WAS OBTAINED BY AVERAGING THE DATA (1044) FOR TWO PLANTS, ONE PRODUCING 1000 T OF COKE PER DAY AND THE OTHER 616 T OF COKE/DAY. IN 1971 1.67 T OF COAL WAS REQUIRED TO PRODUCE A T OF COKE (1036,13). ASSUMING AN AVERAGE CALORIC VALUE OF COAL RECEIVED AT COKING PLANTS OF 13000 BTU/LB (FOOTNOTE 1047) THE EFFLUENT BREAKDOWN IS AS FOLLOWS

FTN. 1051-1053

	T/1.0E12 BTU
AMMONIA	1.39
CYANIDE	0.02
	1.41
BOD_5	0.747
PHENOL	0.117
SUSPENDED SOLIDS	8.45

THERE IS LITTLE OR NO THERMAL DISCHARGE FROM BEEHIVE OVENS (1044).

1051

IN 1971 THE AVERAGE COST OF SHIPPING COAL BY BARGE WAS $0.97/T OF COAL (0031,37). OF THE TOTAL OPERATING EXPENSES APPROXIMATELY 12P (INCLUSIVE OF DEPRECIATION, INSURANCE) IS FIXED COST (0031,8,9), WHICH AGREES WITH DATA IN REF.(0032,18). IN TERMS OF ENERGY THE AVERAGE FREIGHT CHARGE IS $40,400/1.0E12 BTU. THE FIXED AND OPERATING COST DOES NOT ADD TO TOTAL COST BECAUSE OF INDEPENDENT ROUNDING.

1052

FOR RAILROAD FREIGHT SERVICE,THE FIXED COST IS ABOUT 6P (DEPRECIATION ONLY) OF THE TOTAL OPERATING EXPENSES (0033,67/70). IT IS ASSUMED THAT THIS FIGURE APPLIES TO BOTH UNIT AND MIXED TRAINS. SEE FOOTNOTE 1044 AND 1045 FOR FREIGHT CHARGES. THE FIXED AND OPERATING COSTS MAY NOT ADD TO TOTAL COSTS BECAUSE OF INDEPENDENT ROUNDING.

1053

WHEN A CONVEYOR IS USED FOR DISTRIBUTION OF COAL,IT IS GENERALLY USED IN CONJUNCTION WITH ANOTHER MODE OF TRANSPORTATION, E.G., BARGE OR TRAIN. THE HAULAGE DISTANCE IS RELATIVELY SHORT. ONE OF THE LONGER (12 MI) SYSTEMS IS IN OPERATION IN WESTERN KENTUCKY (1045) UTILIZING A CABLE DRIVEN CONVEYOR.

HERE, IT IS ASSUMED THAT THE TRANSPORT DISTANCE IS 5 MI AND A CONVENTIONAL CONVEYER SYSTEM IS USED. THE ECONOMIC ANALYSIS IS AS FOLLOWS (1043,589/609)

CAPITAL EXPENDITURE	1972 $	
BELT	1,220,000	
MACHINERY	1,109,000	
ELEVATED STRUCTURE	1,580,000	
DRIVES & ELECT. EQUIPT.	192,000	
TOTAL CAPITAL	4,101,000	
ERECTION & INSTALLATION (25P)	1,025,000	
TOTAL	5,126,000	
OPERATING EXPENSES	1972 $/YR	$/1.0E12 BTU
BELT REPLACEMENT	85,400	
REPAIR & MAINTENANCE	118,600	
POWER($0.015/KWH)	25,800	
LABOR	18,900	
TOTAL OPERATING	249,000	5100
FIXED COST (10P OF CAPITAL COST)	512,600	10500

THE CONVEYER IS DESIGNED TO HANDLE 2 MMT/YR (1000 TPH AT 8 HR PER DAY, 240 DAY/YR). THE STRUCTURE IS COVERED AND THUS FUGITIVE DUST IS NOT A PROBLEM. WAGE RATES ARE OBTAINED FROM REF.(1042,43) FOR ONE LABORER AND ONE EQUIPMENT OPERATOR.

1054

THE LENGTH OF THE CONVEYER IS 5 MI (FOOTNOTE 1053). THUS, ASSUMING A RIGHT-OF-WAY OF 30 FT, 18.2 AC OF LAND IS OCCUPIED. THE SYSTEM TRANSPORTS 2 MMT OF COAL ANNUALLY. THEREFORE, IN TERMS OF ENERGY, 0.178 AC-YR/1.0E12 BTU OF LAND IS UTILIZED.

1055

THE COST OF TRANSPORTING COAL BY SLURRY PIPELINE IS APPROXIMATELY $0.0061/TMI (1046,FIG.8), WHICH INCLUDES THE COSTS OF SLURRY PREPARATION AND PIPELINE TRANSPORT. OF THE UNIT COST ABOUT 70P IS RELATED TO FIXED CHARGES, 15P IS FOR POWER COSTS AND THE REMAINDER FOR MAINTENANCE (1046).

THE ONLY PIPELINE IN OPERATION IS 273 MI IN LENGTH (FOOTNOTE 1017). THUS, THE COST AMOUNTS TO $1.67/T OR $69,300/1.0E12 BTU.

THE NATIONAL AVERAGE HEAT VALUE (12,180 BTU/LB) IS USED IN THE ABOVE CONVERSION. THE CALORIC VALUE OF COAL FROM BLACK MESA IS ABOUT 12,300 BTU/LB (AS RECEIVED), BUT BECAUSE OF THE MOISTURE ACQUIRED FROM THE SLURRY, THE AS BURNED HEATING VALUE IS SOMEWHAT LOWER.

1056

THE INJURY STATISTICS ARE OBTAINED FROM REF.(0001,135) AND THE COKE TO COAL CONVERSION FROM (0001,428). THE STATISTICS ENTERED IN THE TABLES ARE AVERAGES FOR THE YEAR 1965-1969. THE HEATING VALUE OF THE COAL RECEIVED AT COKING PLANTS IS ASSUMED TO BE 13000 BTU/LB (FOOTNOTE 1047).

1057

THE COST FOR HAULING COAL BY TRUCK IS ABOUT $0.45/T (1047,5-9) FOR A 10 MI TRIP. THUS, TO HAUL 41,000 T (FOOTNOTE 1001) THE COST AMOUNTS TO $18,500.

OF THE TOTAL ANNUAL EXPENDITURE, ABOUT 10P IS RELATED TO FIXED COST (0034,10). THE FIXED AND OPERATING COSTS DO NOT ADD TO THE TOTAL BECAUSE OF INDEPENDENT ROUNDING.

1058

THE FIGURES GIVEN ARE FOR STORAGE WHICH REQUIRES STACKING AND RECLAIMING CONVEYERS AND A BULLDOZER (1047,3). THE SPECIFICATIONS FOR THE CONVEYER SYSTEM ARE OBTAINED FROM REF.(1041,16). THE ECONOMIC ANALYSIS IS AS FOLLOWS (1043,589/609)

CAPITAL EXPENDITURE	1972 $
STORAGE & RECLAIM CONVEYER	
BELT	55,000
INTERMEDIATE MACH. & STRUCTURE	55,000
ELEVATED STRUCTURE	87,000
DRIVES & ELECT. EQUIPMENT	100,000
SUB TOTAL	297,000
ERECTION & INSTALLATION (25P)	74,000
SUB TOTAL	371,000
BULLDOZER (1)	72,000
TOTAL	443,000

FTN. 1059-1061

OPERATING EXPENSES	1972 $/YR	$/1.0E12 BTU
BELT REPLACEMENT-(SINKING FUND RETURNING FULL VALUE AT 4P AT END OF 5 YRS)	54,000	
REPAIR & MAINTENANCE		
5P OF BELT COST	3,000	
2P OF EQUIPMENT COST	5,000	
POWER AT $0.015/KWH	11,000	
LABOR		
CONVEYER	19,000	
BULLDOZER	20,000	
TOTAL	112,000	2300
FIXED COST (10P OF CAPITAL COST)	44,300	908

THE LABOR COSTS INVOLVE AN OPERATOR AND LABORER FOR THE CONVEYER SYSTEM & AN OPERATOR AND MECHANIC FOR THE BULLDOZER (1042,44). ALL COSTS ARE ADJUSTED TO 1972 DOLLARS (FOOTNOTE 1049).

THE SYSTEM HANDLES 2 MMT OF COAL/YR WITH AN AVERAGE HEAT VALUE OF 12,180 BTU/LB.

1059

ALTHOUGH THERE IS MORE SITE PREPARATION INVOLVED IN UNDERGROUND STORAGE, THE ANNUAL EXPENDITURES ARE ASSUMED TO BE SIMILAR TO THAT FOR ABOVE GROUND STORAGE (FOOTNOTE 1058). IN PRACTICE UNDERGROUND STORAGE IS NOT A COMMON METHOD.

1060

THE CONVEYER SYSTEM FOR SILO STORAGE IS SIMILAR TO THAT FOR ABOVE GROUND STORAGE (FOOTNOTE 1058). HENCE, THE COST IS ALSO THE SAME, EXCEPT THAT THE COSTS ASSOCIATED WITH THE BULLDOZER DO NOT APPLY HERE. THE COST OF A SILO IS ASSUMED TO BE SIMILAR TO THAT FOR A BULK STORAGE BUILDING (1041,71). THUS, THE COST IS AS FOLLOWS FOR A 2E6 TPY OPERATION.

CAPITAL EXPENSE	$	$/1.0E12 BTU
SILO	180,000	
OPERATING EXPENSE		
CONVEYER SYSTEM		
OPERATION, REPAIR & MAINT.	112,000	2300
CONVEYOR FIXED COST (10P OF CAPITAL COST)	37,100	761
SILO		
FIXED COST(10P OF CAPITAL COST)	18,000	370

1061

THE ACCIDENT STATISTICS FOR COAL IN 1970 ARE INCLUDED IN THE 'NOT ELSEWHERE CLASSIFIED' CATEGORY IN REF.(0036,14). IN MATCHING DATA WITH REF. (0037,2/9) IT HAS BEEN DEDUCED THAT IN 1970 METALLIC ORES, COAL, NON-METALLIC MINERALS ANL WASTE AND SCRAP METALS WERE INCLUDED IN THIS CATEGORY. OF THE TOTAL TONNAGE OF THESE COMMODITIES COAL ACCOUNTS FOR 3P -- A TRANSPORT OF 341,000 TONS. OF THE TOTAL TONNAGE OF COAL SHIPPED, 1.0E12 BTU EQUIVALENT T AMOUNTS TO 12P. HENCE, 0.0324 FATALITIES/1.0E12 BTU AND 0.692 NON-FATAL INJURIES/1.0E12 BTU ARE ATTRIBUTED TO THE SHIPMENT OF COAL. FOR THE SAME YEAR THE NUMBER OF DAYS LOST PER INJURY FOR 'TRUCKING, LOCAL AND LONG DISTANCE' WAS 65.6 (0038,375). THUS, 45.4 DAYS ARE LOST/1.0E12 BTU.

1062

IT TAKES ABOUT ONE TON OF COAL TO DRY 100 TONS OR 1.0E10 BTU/YR TO DRY 1.0E12 BTU/YR COAL (1048). MEASURED EMISSIONS FROM COAL THERMAL DRYERS ARE 4.5E-2 LB SOX AND 5.35E-1 LB NOX (MID-RANGE VALUES) PER 1.0E6 BTU OF COAL FIRED (1121).

1063

DURING THE TRANSPORT OF FOSSIL FUELS BY RIVER BARGES IN 1971, 3 FATALITIES AND 5 NON-FATAL INJURIES OCCURED (1049). IN THE SAME YEAR 70P OF THE TOTAL TONNAGE OF FOSSIL FUEL SHIPPED WAS COAL (0031,37,40). THUS, 1.93E-3/1.0E12 BTU FATALITIES AND 3.21E-3/1.0E12 BTU INJURIES ARE ATTRIBUTED TO THE TRANSPORT OF COAL.

THE AVERAGE DAYS LOST PER INJURY FOR MARINE CARGO HANDLERS FOR THE PERIOD FROM 1963-1967 IS 75.7 (0038,375). HENCE, 0.243 DAYS LOST/1.0E12 BTU HANDLED.

1064

FUEL CONSUMPTION IS 3530 GAL OF DIESEL/1.0E12 BTU EQUIVALENT T HAULED. FOR A CALORIC CONTENT OF 5.86E6 BTU/BBL, 4.93E8 BTU OF ENERGY ARE CONSUMED (FOOTNOTE 1003).

1065

THE CONVEYOR SYSTEM CONSUMES 1.03E6 KWH/YR OR ABOUT 21100 KWH/ 1.0E12 BTU (FOOTNOTE 1049). THIS IS EQUIVALENT TO 2.20E8 BTU, WHICH IS 3 TIMES THE BTU EQUIVALENT OF THE POWER CONSUMPTION.

1066

THE PRODUCTION COST FOR AN AUGERING OPERATION OF 222,000 T/YR IS AS FOLLOWS (1052)

	$/YR	$/1.0E12 BTU IN
OPERATING COST	346,000	29,400
FIXED COST (10% OF CAPITAL EXPENSE)	43,000	3,650

THE COST OF HAULING THE COAL TO THE TIPPLE IS EXCLUDED FROM THE ABOVE FIGURES.

1067

THE PRODUCTION COST FOR A 2 MMT/YR AREA STRIPPING OPERATION IS ESTIMATED FROM INFORMATION ON A 1 AND 3 MMT/YR MINE IN WESTERN KENTUCKY (1041,27/37,49/60). THE BREAKDOWN IS AS FOLLOWS

1972	1.0E6 $/YR	$/1.0E12 BTU IN
OPERATING COST	4.17	69200
FIXED COST	2.05	34000

THE COSTS OF HAULAGE TO TIPPLE AND TRAIN LOADING FACILITIES ARE EXCLUDED FROM THE ABOVE FIGURES. THE COSTS ARE ESCALATED TO 1972 DOLLARS BY THE INDUSTRIAL WHOLESALE PRICE INDEX (0011,341).

1068

THE PRODUCTION COST FOR A 2 MMT/YR CONTOUR MINING OPERATION IS ESTIMATED FROM INFORMATION IN REF. (1041,1/26) AND IS AS FOLLOWS

1972	1.0E6 $/YR	$/1.0E12 BTU IN
OPERATING COST	4.71	77200
FIXED COST	2.11	34600

THE COSTS HAVE BEEN ADJUSTED TO 1972 DOLLARS BY THE INDUSTRIAL 999
WHOLESALE PRICE INDEX (0011,342). 1099
IT SHOULD BE NOTED THAT ALTHOUGH THE COSTS IN REF. (1041) ARE 1199
DEVELOPED FOR MINES WITH DIFFERENT SPECIFICATIONS,THE COST 1299
PER UNIT ENERGY SHOULD NOT BE IN GREAT ERROR, SINCE FOR 1399
MODERATE SEAM THICKNESS THE COST PER UNIT ENERGY APPEARS TO 1499
BE SENSITIVE ONLY TO THE SIZE OF THE MINE. 1599
HAULAGE TO TIPPLE AND TRAIN LOADING FACILITIES IS EXCLUDED 1699
FROM THE ABOVE COSTS. 1799

1069 199

THE FUGITIVE DUST GENERATED FROM THE HANDLING OF RAW COAL AT THE 299
PREPARATION PLANT IS IN GENERAL CONFINED TO THE PLANT PROPER. 399
IT APPEARS TO PRESENT AN OCCUPATIONAL HEALTH TYPE OF PROBLEM, 499
RATHER THAN ONE OF AIR POLLUTION, PER SE. (1058). 599
AS A CONSEQUENCE OF THE FEDERAL COAL MINE HEALTH AND SAFETY 699
ACT OF 1969, THE R.O.M. COAL FROM UNDERGROUND MINES HAS BEEN 799
HIGHER IN SURFACE MOISTURE (DUE TO THE USE OF INCREASED 899
QUANTITIES OF WATER FOR DUST SUPRESSION). THUS, THE DUST 999
GENERATED FROM HANDLING THESE COALS HAS BEEN REDUCED IN 1099
RECENT YEARS. 1199

1070 199

FOR A SLOPE OF 40 DEGREES (IN CASES WHERE THE SLOPES ARE LESS 299
STEEP IT IS MORE LIKELY THAT THE COAL WILL BE EXTRACTED BY 399
STRIP MINING. AUGERING MAY THEN FOLLOW,(REF. 1051,30)). A 499
BENCH WIDTH OF 35 FT AND A BENCH LENGTH OF 1607 FT. 41300 T/ 599
1.0E12 BTU IN OF SOLID WASTE IS PRODUCED (FOOTNOTE 1026). 699

1071 199

THE PLANT FOR UTILITY COAL PREPARATION IS ASSUMED TO PROCESS 500 299
T/HR (1010). THE R.O.M. COAL IS CRUSHED TO A 1.5 IN. TOPSIZE. 399
THE 1.5 X 3/8 IN. SIZES ARE PROCESSED IN A DENSE MEDIUM BATH 499
AT A SEPARATION SPECIFIC GRAVITY OF 1.6, WHILE THE COALS LESS 599
THAN 3/8 IN. IN SIZE ARE NOT SUBJECTED TO ANY CLEANING. 699
799
THE ASH AND SULFUR COMPOSITION OF THE COAL FROM THE UPPER 899
FREEPORT BED IN CLEARFIELD COUNTY, PA. IS VERY SIMILAR TO THE 999
CHARACTERISTICS OF THE AVERAGE (OVER MOST OF THE COUNTRY) 1099
UTILITY COAL (14.4P ASH, 3.23P S, REF. 1053,16). THEREFORE, 1199
THE WASHABILITY DATA OF THE UPPER FREEPORT COAL (1053,130) 1299
ARE UTILIZED. AT A SEPARATION SPECIFIC GRAVITY OF 1.6 THE 1399
DATA INDICATE A THEORETICAL CLEAN COAL RECOVERY OF 90.3P. 1499
A STUDY OF 6 DENSE MEDIUM WASHERS REVEALED AN AVERAGE 1599
EFFICIENCY OF 96.9P (1054,28). THUS, IT IS ASSUMED THAT THE 1699
ACTUAL RECOVERY OF CLEAN COAL IS 87.5P. 1799
SINCE NO SCREEN ANALYSIS IS AVAILABLE ON THE UPPER FREEPORT 1899
COAL THE DATA ON THE LOWER KITANNING BED OF ARMSTRONG COUNTY, 1999
PA. (WHICH HAVE SOMEWHAT SIMILAR CHARACTERISTICS) ARE USED. 2099
OF THE CRUSHED COAL,THE 1.5 X 3/8 IN.SIZE FRACTION CONSTITUTES 2199
72P (1055). HENCE, THE DENSE MEDIUM BATH IS FED AT A RATE OF 2299
360 T/HR PRODUCING CLEAN COAL AT A RATE OF 314T/HR AND SOLID 2399
WASTE AT A RATE OF 45.5 T/HR OR 3740 T/1.0E12 BTU IN. 2499
AN ADDED SOURCE OF REFUSE IS THE MAGNETITE LOSSES DURING 2599
PROCESSING. THE AVERAGE LOSS OF MAGNETITE AMOUNTS TO 0.9 LB/ 2699
TON OF CLEAN COAL. THUS, AN ADDITIONAL AMOUNT OF 11.6 T/1.0E12 2799

BTU OF SOLID IS PRODUCED (REF. 1054) 2899
THE COLLECTING OF TRAMP IRON AMOUNTS TO 2.46 T/1.0E12 BTU 2999
(FOOTNOTE 1035). THE SUM TOTAL SOLID WASTE GENERATED IS THUS 3099
3.75E03 TON/1.0E12 BTU. 3199

1072 199

SEEPAGE FROM THE REFUSE PILE IS ESTIMATED TO BE 1670 GAL/AC-DAY 299
AND CONTAINS .091 LB ACIDITY/GAL, .144 LB SULFATES/GAL, 399
.0258 LB IRON/GAL, AND 3.78E-4 LB MN/GAL. (1009). THUS, THE 499
DRAINAGE WILL CONTAIN 599

T/1.0E12 BTU 699
799

SULFATES	31.5	899
MANGANESE	0.08	999
IRON	5.6	1099
TOTAL	37.2	1199
ACIDITY	19.9	1299

1399

OF THE RAW CRUSHED COAL 1P IS LESS THAN 100 MESH IN SIZE 1499
(1055). A PROPORTION OF THIS SIZE FRACTION ENDS UP IN THE FEED 1599
TO THE DENSE MEDIUM CIRCUIT. ASSUMING 10P OF THE COAL LESS 1699
THAN 100 MESH IN SIZE IS YIELDED AS BLACKWATER DISCHARGE, 1799
SUSPENDED SOLIDS ARE GENERATED AT A RATE OF 0.5 T/HR. IT IS 1899
UNREALISTIC TO ASSUME THAT ALL OF THE BLACKWATER IS DISCHARGED 1999
TO NATURAL DRAINAGE OF THAT THE PLANT OPERATES ON A CLOSED 2099
CYCLE. OF THE 685 PLANTS APPLYING FOR PERMITS THROUGH EPA 37.5 2199
P HAVE TREATMENT FACILITIES (1112). RATHER THAN APPLYING ANY 2299
TREATMENT, THE BLACKWATER IS ASSUMED TO BE DISCHARGED TO A 2399
SETTLING POND AND 62.5P OF THE BLACKWATER GENERATED ENTERS THE 2499
NATURAL DRAINAGE THROUGH LEAKS, OVERFLOWS AND IMPROPER SET- 2599
TLING. THUS, 25.6 T/1.0E12 BTU OF SUSPENDED SOLIDS ARE DIS- 2699
CHARGED. SOME MINERALS WILL ALSO BE DISCHARGED AS DISSOLVED 2799
SOLIDS, BUT NO DATA HAS BEEN LOCATED. 2899
SEDIMENT YIELD FROM THE REFUSE PILE OCCURS AT A RATE OF 2999
2.54 T/AC-YR-IN. OF RUNOFF. THUS, FOR AN AVERAGE RUNOFF OF 3099
15 IN. AND A REFUSE PILE AREA OF 0.718 AC-YR/1.0E12 BTU IN 3199
(FOOTNOTE 1073), THE SEDIMENT YIELD IS 27.4 T/1.0E12 BTU IN. 3299
THE TOTAL SUSPENDED SOLIDS DISCHARGED TO NATURAL DRAINAGE IS 3399
53.0 T/1.0E12 BTU IN. 3499

1073 199

THE REFUSE BANK IN A PILE AVERAGING 30 FT IN HEIGHT OCCUPIES AN 299
AREA OF .0574 AC/1.0E12 BTU. (SOLID WASTE PRODUCTION, FOOTNOTE 399
1071). THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS THERE- 499
FORE 0.718 AC-YR/1.0E12 BTU. 599
LAND REQUIRED FOR THE PREPARATION PLANT IS ABOUT 5 AC (1008). 699
THE LOADING AREA FOR A 10000 T UNIT TRAIN IS ESTIMATED TO BE 799
ABOUT 40 AC (DATA ON THE MATTHEWS MINE, (1006,85) AND THE 899
SETTLING POND OCCUPIES ABOUT 50 AC (1009). THE PLANT PROCESSES 999
2 MMT/YR, THUS THE LAND IMPACT IS 1.95 AC-YR/1.0E12 BTU. 1099
IT IS ASSUMED THAT BOTH THE STEAM AND METALLURGICAL PLANTS 1199
HAVE SIMILAR LAND REQUIREMENTS, SINCE THE EQUIPMENT 1299
DOES NOT OCCUPY LARGE AREAS. 1399
FOR THE METALLURGICAL PLANT THE SOLID WASTE PILE OCCUPIES 1499
0.124 AC/1.0E12 BTU (SOLID WASTE PRODUCTION, FOOTNOTE 1813). 1599
THE TIME AVERAGED LAND IMPACT IS 1.55 AC-YR/1.0E12 BTU. 1699

1074 199

A MAJORITY OF ACTIVE AND INACTIVE COAL WASTE BANKS SURVEYED (1067, 299
1068) WERE FOUND BURNING OR SMOLDERING, ADDING TO THE PROBLEM 399
OF AIR POLLUTION. IT IS ASSUMED THAT THE REFUSE BANK IN THIS 499
CASE IS BURNING. THE EMISSION FACTORS ARE DETERMINED FROM 599
INFORMATION IN REF. 0017 AND FROM THE KNOWLEDGE OF THE SOLID 699
WASTE PRODUCED (FOOTNOTE 1071), AND ARE AS FOLLOWS 799
899

FTN. 1075-1077

	PART.	SOX	CO	HC	NOX
T/1.0E12 BTU	1.58	2.37	4.75	0.792	0.792

SINCE THE INTERMEDIATE AND FINE SIZE COALS ARE NOT SUBJECTED TO ANY CLEANING (FOOTNOTE 1071) THE ASSOCIATED PROBLEMS ARE NON-EXISTENT.
THE PROBLEM OF FUGITIVE DUST AT THE PREPARATION PLANT IS NOT SIGNIFICANT EXCEPT FOR THE HANDLING OF THERMALLY DRIED FINES (1048). THE FEDERAL COAL MINE HEALTH AND SAFETY ACT OF 1969 HAS LED TO AN INCREASED USE OF WATER FOR DUST SUPPRESSION IN UNDERGROUND MINES. CONSEQUENTLY THE SURFACE MOISTURE OF THE R.O.M. COAL HAS INCREASED AND THEREBY REDUCED THE FUGITIVE DUST PROBLEMS AT TRANSFER POINTS AND AT THE CRUSHERS. SEE FOOTNOTE 1077.
THE DUST PROBLEM FROM WIND EROSION OF THE STORAGE PILES IS MINIMAL DUE TO THE RELATIVELY RAPID MOVEMENT OF THE PILES.

1075

THE COSTS FOR OPERATING A PREPARATION PLANT CLEANING THE 1.5 IN. X 3/8 IN. IN A DENSE MEDIUM BATH ARE AS FOLLOWS (1056,34/36) FOR A 2 X 10^6 TPY PLANT

	1.0E6 $	
CAPITAL EXPENSE	1.18	
	1.0E6 $/YR	$/1.0E12 BTU
OPERATING EXPENSE	0.265	5520
FIXED COST (10P OF CAPITAL EXPENSE)	0.118	2480

THE REFUSE DISPOSAL COSTS ARE OBTAINED BY ADJUSTING THE DATA IN REF. 1057. ONE 13 T TRUCK IS USED FOR HAULING THE REFUSE. FROM THE INFORMATION ON ALTERNATE DISPOSAL METHOD FOR THE KENTUCKY MINE (1057,11/12) THE DISPOSAL COSTS ARE ESTIMATED TO BE AS FOLLOWS

	1.0E5 $	
CAPITAL EXPENSE	1.79	
	1.0E5 $/YR	$/1.0E12 BTU
OPERATING EXPENSE	1.71	3560
FIXED COST (10P OF CAPITAL EXPENSE)	0.18	380

1076

THE COSTS INVOLVED IN OPERATING A PLANT FOR SIMPLE CRUSHING AND SIZING OF R.O.M. COAL ARE AS FOLLOWS (1056,IV-34/36) FOR A 2E6 TPY PLANT.

	1.0E4 $ (1972)	
CAPITAL EXPENSE	14.4	
		$/1.0E12 BTU IN
OPERATING EXPENSE	9.36	1950
FIXED COST (10P OF CAPITAL EXPENSE)	1.44	300

IN ESTIMATING THE COSTS IT HAS BEEN ASSUMED THAT 60P OF THE CRUSHED COAL CAN BE CLASSIFIED AS COARSE (1.5 IN. X 3/8 IN.).

1077

THE FUGITIVE DUST PROBLEM ASSOCIATED WITH PREPARATION PLANTS IS IN GENERAL CONFINED TO THE IMMEDIATE SITE (1058). IT APPEARS TO BE MORE OF AN OCCUPATIONAL HEALTH PROBLEM.
IN THE HANDLING OF R.O.M. COAL FROM UNDERGROUND MINES THIS PROBLEM HAS DECREASED IN RECENT YEARS. FOLLOWING THE ENACTMENT OF THE FEDERAL COAL MINE HEALTH AND SAFETY ACT IN 1969, A GREATER AMOUNT OF WATER IS BEING USED FOR THE SUPPRESSION OF DUST, THEREBY INCREASING THE SURFACE MOISTURE AND CONSEQUENTLY

REDUCING THE QUANTITY OF DUST GENERATED DURING HANDLING OF THE RAW COAL.

1078

THE QUANTITY OF WATER USED AT TRANSFER POINTS IN A PREPARATION PLANT TO SUPPRESS DUST IS VERY SMALL (1058). THUS, ONLY SMALL QUANTITIES OF WATER, IF ANY, MAY BE DISCHARGED. IT DOES NOT SEEM LIKELY THAT STREAM QUALITY WILL BE AFFECTED EXCEPT POSSIBLY AT THE OUTFALL.
IT SHOULD BE NOTED THAT NOT ALL PLANTS UTILIZE WATER FOR DUST SUPRESSION. MANY PLANTS DO NOT APPLY ANY CONTROL MEASURES.

1079

DISASTERS (A SINGLE ACCIDENT RESULTING IN 5 OR MORE DEATHS) OCCUR FREQUENTLY IN UNDERGROUND MINES. IN THE PAST 40 YRS ONLY 6 CALENDAR YEARS WENT WITHOUT A DISASTER OCCURING.
SINCE IN LONGWALL MINING THE ROOF IS COLLAPSED AS MINING PROGRESSES, UNEXPECTED ROOF FAILURE IS AVOIDED. THUS, IT WILL BE LESS HAZARDOUS.

1080

THE POTENTIAL FOR DISASTERS TO OCCUR DURING AUGER MINING IS MINIMAL. ONLY THE FAILURE OF THE HIGHWALL PRESENTS ANY REAL HAZARD TO THE WORKERS.

1081

LARGE SCALE DISASTERS AT STRIP MINES ARE RARITIES. AS IN AUGER MINING ONLY THE FAILURE OF THE HIGHWALL PRESENTS ANY POTENTIAL FOR A DISASTER.

1082

THE POTENTIAL FOR LARGE SCALE DISASTERS IS NON-EXISTENT.

1083

FUEL CONSUMPTION BY THE UNIT TRAIN IS 1.03E5 GAL/1.0E12 BTU EQUIVALENT T TRANSPORTED. (FOOTNOTE 1005). FOR A CALORIC VALUE OF 5.825E6 BTU/BBL, 1.43E10 BTU OF ENERGY IS CONSUMED.

1084

FUEL CONSUMPTION BY MIXED TRAIN IS 81000 GAL/1.0E12 BTU EQUIVALENT T TRANSPORTED (FOOTNOTE 1007). THIS AMOUNTS TO AN ENERGY CONSUMPTION OF 1.12E10 BTU (5.825E6 BTU/BBL).

1085

A BARGE CONSUMES 378 BTU/TMI (FOOTNOTE 7001). THUS, FOR AN AVERAGE HAULAGE DISTANCE OF 300 MI (FOOTNOTE 1006) AND AN ASSUMED GROSS TO TARE WEIGHT RATIO OF 4 TO 1, 7.76E9 BTU OF ENERGY IS CONSUMED FOR THE TRANSPORT OF 1.0E12 BTU EQUIVALENT T.

1086

ENERGY CONSUMPTION FOR THE TRANSPORT OF COAL BY PIPELINE AMOUNTS TO 6.93E5 KWH (FOOTNOTE 1055 ASSUMING $.015/KWH). THE REAL CONSUMPTION OF ENERGY IS THE PRODUCT OF THE BTU EQUIVALENT (OF 6.93E5 KWH) AND 3.

1087

FUEL CONSUMPTION FOR THE TRANSPORT 1.0E12 BTU EQUIVALENT T BY TRUCK AMOUNTS TO 6600 GAL OR 9.17E8 BTU (5.83E6 BTU/BBL) (FOOTNOTE 1008).

1088

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYORS IS 3.53E4 KWH/1.0E12 BTU (FOOTNOTE 1053). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF 3.53E4 KWH.

1089

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYORS FOR STORAGE AMOUNTS TO 1.52E4 KWH./1.0E12 BTU (FOOTNOTES 1058,1059, 1060). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER.

1090

IT HAS BEEN ESTIMATED THAT DURING LONGWALL MINING PHYSICAL LOSSES AMOUNT TO APPROXIMATELY 15P (1060).

FTN. 1091-1804

1091

ESTIMATES FOR ROOM AND PILLAR UNDERGROUND MINES INDICATE THAT LOSSES AMOUNT TO ABOUT 43P (1060 AND 1061).

1092

THE RECOVERY EFFICICIENCY FOR AUGER MINING IS ESTIMATED TO BE 46P (1062).

1093

PHYSICAL LOSSES DURING CONTOUR MINING AMOUNT TO ABOUT 20P (1063).

1094

PHYSICAL LOSSES DURING AREA STRIPPING AMOUNT TO APPROXIMATELY 19P (1063). THE RECOVERY PERCENTAGE FOR AREA STRIPPING HAS A GREATER VARIABILITY THAN CONTOUR MINING. THE UPPER LIMIT IS IN THE VICINITY OF 98P.

1095

ENERGY CONSUMPTION AT A CRUSHING AND SIZING PLANT IS ABOUT 1.6E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION 1.4E5 KWH IS ELECTRICITY (1064,12A-16,39) AND 2.4E8 BTU IS OIL (1064,12A-16,39, ASSUMING ALL FUEL PURCHASED TO BE OIL AT A COST OF $0.20/GAL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL CONSUMPTION TO THE OIL USAGE.

1096

ANCILLARY FUEL CONSUMPTION DURING COKE PRODUCTION IN BOTH BEEHIVE AND SLOT OVENS IS NIL.

1097

LOSSES (DUE TO OXIDATION) IN HEAT CONTENT OF THE COAL IN AN ACTIVE STORAGE PILE ARE NEGLIGIBLE, WHILE IN DEAD STORAGE THE LOSSES AMOUNT TO ABOUT 1P/YR FOR OPEN (ABOVE AND UNDERGROUND) PILES AND 0.7P/YR FOR SILOS (1047 AND 1065). THESE FIGURES ASSUME PROPER STORAGE TECHNIQUES ARE EMPLOYED. OTHERWISE THE LOSSES DURING THE FIRST YR MAY AMOUNT TO 3-5P. IN GENERAL, THE LOWER THE RANK OF COAL, THE GREATER WILL BE THE LOSSES.

1098

COAL LOSSES DURING HAULAGE FROM MINE TO TIPPLE ARE ASSUMED TO BE NEGLIGIBLE.

1099

THE AMOUNT OF FEED REMOVED AS TRAMP IRON IS MINISCULE (0.006P). THE EFFICIENCY IS THEREFORE APPROXIMATELY 100P.

1801

WINDAGE LOSSES FOR UNIT TRAIN, BARGE AND TRUCKING AMOUNTS TO .04 P (FOOTNOTES 1005,1006,1008), WHILE FOR MIXED TRAIN LOSSES AMOUNT TO .08P (FOOTNOTE 1007).

1802

AN ESTIMATED THERMAL EFFICIENCY REDUCTION OF ABOUT 2P RESULTS FROM THE SLURRY WATER REMAINING IN THE BOILER FEED (1006,6-24). THIS LOSS IS CONSIDERED TO BE EFFECTIVELY A REDUCTION IN THE HEATING VALUE OF THE COAL AND ATTRIBUTABLE TO THE MODE OF TRANSPORT.

1803

IT IS ASSUMED THAT ABOUT .04P OF THE COAL TRANSPORTED IS LOST THROUGH SPILLAGE AT TRANSFER POINTS. SINCE THE CONVEYOR IS COVERED, NO WINDAGE LOSSES ARE ASSUMED.

1804

BY LINEARLY INTERPOLATING THE DATA IN REF. (1041,12,22), AND ASSUMING THE OILS TO BE DIESEL FUELS COSTING $.20/GAL AND THE COST OF POWER TO BE $.015/KWH THE TOTAL ENERGY CONSUMPTION FOR A 2 MMT CONTOUR STRIPPING OPERATION IS ABOUT 1.34E10 BTU FOR EVERY 1.0E12 BTU EQUIVALENT T EXTRACTED. THE TOTAL IS COMPOSED OF 1.84E9 BTU OF FUEL AND 1.13E6 KWH OF ELECTRICAL POWER. THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER USAGE TO THE FUEL CONSUMPTION. ON A 1.0E12 BTU IN BASIS THE TOTAL IS 1.07E10 BTU.

1805

THE ASSUMPTION IS MADE HERE THAT THE CHARACTERISTICS OF THE WASTE PRODUCTS AND EFFLUENT FROM COAL CLEANING PLANTS WILL DEPEND PRIMARILY ON THE PROPERTIES OF THE INPUT COAL, I.E., THE WASHABILITY CHARACTERISTIC OF THE COAL RATHER THAN ON SPECIFIC EQUIPMENT IN THE PLANT.

IN GENERAL, ALL COAL IS MECHANICALLY CRUSHED AND SIZED, BEFORE USING IT AS A FUEL OR RAW MATERIAL. APPROXIMATELY 50P OF ALL THE COAL PRODUCED IN THE U.S. IS CLEANED. A SMALL PORTION IS CLEANED FOR PRODUCTION OF COKE FOR METALLURGICAL APPLICATIONS AND THE REST IS CLEANED FOR STEAM RAISING APPLICATIONS. A METALLURGICAL COAL IS DEFINED AS ANY COAL WHICH CAN BE CLEANED TO AN ASH CONTENT BELOW 8P AND A SULFUR CONTENT BELOW 1.25 P USING A LOW WASH SPECIFIC GRAVITY IN THE VICINITY OF 1.4 .

A COAL PREPARED FOR FUEL USE OR STEAM RAISING APPLICATIONS IS GENERALLY CLEANED AT A SPECIFIC GRAVITY NOT LESS THAN 1.6. FROM DATA ON WASHABILITY CHARACTERISTICS OF COAL, ONE CAN DERIVE A RELATION BETWEEN THE MAXIMUM THEORETICAL THERMAL RECOVERY EFFICIENCY, THE INPUT ASH CONTENT OF THE COAL AND THE SPECIFIC GRAVITY OF THE WASH. FROM THE AVERAGED DATA IN REFERENCE (1010) TWO RELATIONS WERE DEVELOPED. FOR A SPECIFIC GRAVITY OF WASHING OF 1.6

P BTU EFFICIENCY = -0.342 (P ASH) + 100.

A SPECIFIC GRAVITY OF WASHING OF 1.4 GIVES

P BTU EFFICIENCY = -1.316 (P ASH) + 100.

THE NATIONAL AVERAGE ASH CONTENT IS 14.4 P FOR UTILITY COAL (1053,229). THUS, WASHING AT A SPECIFIC GRAVITY OF 1.6 YIELDS A 95.1 P THERMAL RECOVERY. THE OVERALL STEAM COAL PLANT THERMAL EFFICIENCY IS THE WEIGHTED AVERAGE OF THE EFFICIENCY FOR THE WASHED AND UNWASHED PORTIONS - 95.1 P AND 100.0 P RESPECTIVELY, OR 96.5 P (SEE FOOTNOTE 1071). THE ASH CONTENT OF COAL PROCESSED FOR METALLURGICAL PURPOSES IS 16.0 PC (FOOTNOTE 1813). HENCE, THE OVERALL EFFICIENCY FOR THE METALLURGICAL PLANT IS 85.2 PC. IN DETERMINING THE OVERALL EFFICIENCY OF THE METALLURGICAL PLANT IT IS ASSUMED THAT THE CALORIC VALUE OF THE FEED INTO EACH PROCESS (DENSE MEDIUM BATH, TABLES AND FLOTATION) IS THE SAME (12,180 BTU/LB). THE DENSE MEDIUM BATH WASHES AT A 1.4 SPECIFIC GRAVITY AND THE CONCENTRATING TABLE AT A 1.6 SPECIFIC GRAVITY. THE THERMAL EFFICIENCY OF THE FLOTATION UNIT IS ASSUMED TO BE 85 PC. THE OVERALL THERMAL EFFICIENCY IS THE WEIGHTED AVERAGE OF THE EFFICIENCIES FOR THE INDIVIDUAL PROCESSES-79 PC, 95 PC, AND 85 PC FOR THE BATH, TABLE AND FROTH FLOTATION, RESPECTIVELY-LESS THAT USED BY THE THERMAL DRYER (FOOTNOTE 1814).

1806

BY LINEARLY INTERPOLATING THE DATA BETWEEN A 1 AND A 3 MMT/YR AREA STRIPPING OPERATION IN WESTERN KENTUCKY (1041,32,54) THE POWER CONSUMPTION FOR A 2 MMT/YR OPERATION IS DETERMINED. IT IS ASSUMED THAT THE OILS ARE DIESEL FUEL COSTING $0.20/GAL AND THE COST OF ELECTRICAL POWER TO BE $0.015/KWH. THE TOTAL ENERGY CONSUMPTION FOR THE EXTRACTION OF 1.0E12 BTU EQUIVALENT T IS COMPUTED TO BE 6.97E9 BTU, WHICH IS COMPOSED OF 1.15E9

BTU OF DIESEL FUEL AND 5.68E5 KWH OF ELECTRICAL POWER. IN 999
OBTAINING THE TOTAL 3 TIMES THE ELECTRICAL POWER USAGE IS 1099
ADDED TO THE FUEL CONSUMPTION. ON A 1.0E12 BTU IN BASIS THE 1199
TOTAL ENERGY CONSUMPTION IS 5.65E09 BTU. 1299

1807 199

NO LOSSES ARE ATTRIBUTED TO THESE PROCESSES EXCEPT FOR ROUGH 299
CLEANING. DURING ROUGH CLEANING TRAMP IRON IS REMOVED AND 399
AMOUNTS TO APPROXIMATELY 0.006 P. 499

1808 199

THE DIESEL FUEL CONSUMPTION FOR AN AREA STRIPPING OPERATION IS 299
ESTIMATED TO 6710 GAL/..0E12 BTU IN (FOOTNOTE 1806). 399
THE EMISSION FACTORS ARE OBTAINED FROM REFERENCE (0002, 499
3-7) ASSUMING THE CHARACTERISTICS OF A DIESEL TRUCK 599
ENGINE. 699
SINCE MOST OF THE COAL PRODUCTION OCCURS IN AREAS WHERE 799
ADEQUATE MOISTURE IS AVAILABLE, FUGITIVE DUST IS NOT EXPECTED 899
TO BE A SERIOUS PROBLEM. 999

1809 199

APPROXIMATELY 1 T OF COAL IS REQUIRED TO DRY 100 T OF COAL (FOOT- 299
NOTE 1062). IN GENERAL, A PORTION OF THE COAL FED TO THE 399
DRIER IS UTILIZED. THUS, THE EFFICIENCY IS 99PC. 499

1810 199

THE OPERATING COST FOR A MCNALLY FLOWDRYER IS $0.08373/T OF DRIED 299
PRODUCT (1074). CAPITAL COSTS ARE ESTIMATED AT 5.5E5 $ FOR 399
A 1.74E6 TPY DRYER OR 1.30E3 $/1.0E12 BTU (1080). 499

1811 199

THE ELECTRICAL POWER CONSUMPTION AMOUNTS TO 1.82 KWH/T OF DRIED 299
COAL PRODUCT OR 7.56E8 BTU/1.0E12 BTU IN (1074). 399

1812 199

APPROXIMATELY 35 AC OF LAND IS UTILIZED FOR THE CRUSHING AND 299
SIZING PLANT, AND A 10000 T UNIT TRAIN LOADING FACILITY 399
(1021). THUS, THE LAND IMPACT IS 0.729 AC-YR/1.0E12 BTU. 499
IT IS ASSUMED THAT THE MODES OF TRANSPORT OTHER THAN UNIT 599
TRAINS HAVE SIMILAR LAND REQUIREMENTS. 699

1813 199

THE METALLURGICAL PREPARATION PLANT PROCESSES 500 T/HR OF R.O.M. 299
COAL (ABOUT 2MMT/YR, FOOTNOTE 1071). AT THE PLANT THE COAL IS 399
CRUSHED TO 1.5 IN. TOPSIZE. THE 1.5 X 3/8 IN. SIZE FRACTION IS 499
WASHED IN A DENSE MEDIUM VESSEL, THE 3/8 X 28 MESH SIZES ARE 599
CLEANED ON CONCENTRATING TABLES, AND THE COAL LESS THAN 28 699
MESH IS CLEANED BY FROTH FLOTATION. 799
THE COAL FROM THE UPPER FREEPORT BED OF THE IRISH RIDGE MINE 899
IN PRESTON COUNTY, W. VA. IS UTILIZED IN THIS ANALYSIS, SINCE 999
IT APPEARS TO REPRESENT A TYPICAL COAL REQUIRING BENEFICIATION 1099
TO MEET METALLURGICAL COKING STANDARDS. THE COAL CONTAINS 1199
16.0PC ASH AND 2.49PC SULFUR (1075,30). 1299
AT A SPECIFIC GRAVITY OF SEPARATION OF 1.4, THE WASHABILITY 1399
DATA INDICATE A THEORETICAL CLEAN COAL RECOVERY OF 78.4PC 1499
(1075,25). FOR A RECOVERY EFFICIENCY OF 96.9PC(1054,28), THE 1599
ACTUAL RECOVERY IS 76PC. 1699
FROM THE DISTRIBUTION DATA ON CONCENTRATING TABLES FOR PLANT E 1799
(1076,10-52) AND THE WASHABILITY DATA, THE THEORETICAL 1899
RECOVERY EFFICIENCY IS ESTIMATED TO BE 88 PC. THE RECOVERY 1999
EFFICIENCY IS ABOUT 98PC(1077), THUS THE ACTUAL CLEAN COAL 2099
RECOVERY IS 86PC. 2199
THE FIXED CARBON CONTENT (DRY AND MINERAL FREE) FOR THIS COAL 2299
IS ABOUT 65PC(1075,30) WHICH IS SIMILAR TO THE UPPER FREEPORT 2399
BED COAL ANALYZED FOR WASHABILITY BY FLOTATION. THUS, USING 2499
THIS DATA, THE THEORETICAL CLEAN COAL RECOVERY BY FROTH FLOT- 2599

ATION IS ESTIMATED TO BE 86.6PC.THE RECOVERY EFFICINCY IS
ABOUT 92PC(1077), THUS THE ACTUAL RECOVERY IS 80.0PC.
THE SCREEN ANALYSIS OF THIS COAL INCLUDES SIZES GREATER THAN
1.5 IN. (1075,30). IT IS ASSUMED THAT THE SIZE DISTRIBUTION
OF THE COAL LESS THAN 1.5 IN. IS SIMILAR WHEN THE COAL IS
CRUSHED TO A TOPSIZE OF 1.5 IN. ON THIS BASIS THE DENSE
MEDIUM BATH WASHES 266 T/HR, THE CONCENTRATING TABLES 200 T/HR
AND THE FLOTATION UNITS 34 T/HR. HENCE, SOLID WASTE IS PRO-
DUCED AT A RATE OF 98.8 T/HR, OR 8100 T/1.0E12 BTU.
THE AVERAGE MAGNETITE LOSSES FROM THE DENSE MEDIUM BATH
AMOUNTS TO 0.9 LB/T OF CLEAN COAL PRODUCED FROM THE BATH
(1054). THUS, AN ADDITIONAL AMOUNT OF REFUSE, 7.47 T/1.0E12
BTU, IS PRODUCED.
AN ADDITIONAL 2.46 T/1.0E12 BTU OF TRAMP IRON IS COLLECTED
DURING ROUGH CLEANING (FOOTNOTE 1035). THE SUM TOTAL SOLID
WASTE GENERATED IS THUS 8.11E03 T/1.0E12 BTU.

1814

THE EMISSIONS ASSOCIATED WITH BURNING COAL REFUSE BANKS ARE AS
FOLLOWS (SOLID WASTE PRODUCTION, FOOTNOTE 1813, SEE ALSO
FOOTNOTE 1074)

	PART.	SOX	CO	HC	NOX
T/1.0E12 BTU	3.41	5.11	10.2	1.71	1.71

THE THERMAL DRIER PROCESSES ALL OF THE COAL LESS THAN 3/8 IN.
IN SIZE (197 T/HR, FOOTNOTE 1813), THUS REQUIRING THE COMBUS-
TION OF 2.00 T OF COAL/HR OR 164 T/1.0E12 BTU. ASSUMING A
FLUIDIZED BED DRIER, THE EMISSIONS ARE AS FOLLOWS (FOOTNOTE
1062 AND REF. (0002,8-10) AND FOOTNOTE 1123).

	PART.	SOX	NOX
T/1.0E12 BTU	48.6	.0967	1.15

THE PARTICULATES ARE REMOVED WITH A 70 P EFFICIENCY BY A
CYCLONE (FOOTNOTE 1002).

1815

THE SEEPAGE FROM THE REFUSE PILE IS CONSTITUTED AS FOLLOWS (SEE
FOOTNOTE 1072)

	T/1.0E12 BTU
FE	12.2
SO4	68.0
MN	.2
TOTAL	80.4
ACIDITY	42.9

OF THE RAW CRUSHED COAL,1.0P IS LESS THAN 100 MESH IN SIZE
(1075,30). IT IS ASSUMED THAT 50P OF THIS SIZE FRACTION ENDS
UP AS BLACKWATER DISCHARGE (FOOTNOTES 1820,1821 AND 1822).
THUS, 205 T/1.0E12 BTU OF SUSPENDED SOLIDS ARE DISCHARGED TO
THE SETTLING POND. OF THIS TOTAL,62.5PC IS ASSUMED TO BE
DISCHARGED TO THE NATURAL DRAINAGE THROUGH LEAKS, OVERFLOWS
AND IMPROPER SETTLING (FOOTNOTE 1072). THIS AMOUNTS TO A
DISCHARGE OF 128 T/1.0E12 BTU OF SUSPENDED SOLIDS. OTHER
MINERALS ARE ALSO DISCHARGED, BUT NO DATA HAS BEEN FOUND.
SEDIMENT YIELD FROM THE REFUSE PILE OCCURS AT A RATE OF 2.54
T/AC-YR-IN. OF RUNOFF. THUS, FOR AN AVERAGE RUNOFF OF 15 IN.
THE SEDIMENT YIELD IS 59.1 T/1.0E12 BTU (LAND USAGE BY REFUSE
PILE, FOOTNOTE 1073).

FTN. 1816-1820

1816

THE COSTS INVOLVED IN OPERATING A PREPARATION PLANT PRODUCING METALLURGICAL QUALITY COAL ARE AS FOLLOWS (1056, IV-34/36) FOR A 2E6 TPY PLANT.

	1.0E6 $	
CAPITAL EXPENSE	2.64	
	1.0E6 $/YR	$/1.0E12 BTU
OPERATING EXPENSE	0.394	8200
FIXED COST (10PC OF CAPITAL EXPENSE)	0.264	5500

THE REFUSE DISPOSAL COSTS ARE OBTAINED BY ADJUSTING THE DATA IN REF.(1057).ONE 60 T TRUCK IS USED FOR HAULING THE REFUSE. FROM THE INFORMATION ON ALTERNATE DISPOSAL METHODS FOR THE KENTUCKY MINE (1057,11/12) THE DISPOSAL COSTS ARE ESTIMATED TO BE AS FOLLOWS

	1.0E5 $	
CAPITAL EXPENSE	2.76	
	1.0E5 $/YR	$/1.0E12 BTU
OPERATING EXPENSE	1.82	3790
FIXED COST (10 PC OF CAPITAL EXPENSE)	0.28	570

1817

THE DENSE MEDIUM BATH IS ASSUMED TO BE CLEANING 1.5 X 3/8 IN. SIZE FRACTIONS AT A 1.4 SPECIFIC GRAVITY OF SEPARATION. THE COAL BEING PROCESSED IS FROM THE UPPER FREEPORT BED OF THE IRISH RIDGE MINE IN PRESTON COUNTY, W. VA. THE CLEAN COAL RECOVERY EFFICIENCY IS 76PC(FOOTNOTE 1813). THUS, FOR THE PROCESSING OF 1.0E12 BTU EQUIVALENT T OF COAL,9850 T OF SOLID WASTE IS PRODUCED.

1818

THE CONCENTRATING TABLE IS ASSUMED TO BE CLEANING 3/8 IN. X 28 MESH SIZE FRACTIONS. FROM THE DISTRIBUTION CURVE DATA ON 5 TABLES (1076,10-52) AND THE WASHABILITY DATA OF THE COAL (1075,25), THE THEORETICAL CLEAN COAL RECOVERY IS ESTIMATED TO BE 88 PC. THE RECOVERY EFFICIENCY IS ABOUT 98PC(1077), THUS THE ACTUAL CLEAN COAL RECOVERY IS 86 PC.THUS, FOR THE PROCESSING OF 1.0E12 BTU EQUIVALENT T, 5740 T OF SOLID WASTE IS GENERATED.

1819

THE COAL LESS THAN 28 MESH IN SIZE IS PROCESSED BY FROTH FLOTATION. THE COAL FROM THE UPPER FREEPORT BED OF THE IRISH RIDGE MINE IN PRESTON COUNTY, W. VA., CONTAINS ABOUT 65 PC FIXED CARBON (DRY AND MINERAL FREE). THIS IS SIMILAR TO THE FIXED CARBON CONTENT OF UPPER FREEPORT BED OF HARMAVILLE, PA., FOR WHICH FLOTATION WASHABILITY STUDIES WERE CONDUCTED. THE DATA INDICATE A THEORETICAL RECOVERY OF 86.6PC(1078,29). THE RECOVERY EFFICIENCY IS ABOUT 92PC(1077), THUS THE ACTUAL CLEAN COAL RECOVERY IS 80 PC. SOLID WASTE IS THEREFORE GENERATED AT A RATE OF 8200 T/1.0E12 BTU.

1820

OF THE RAW CRUSHED COAL 1P IS LESS THAN 100 MESH IN SIZE (1075,30 AND FOOTNOTE 1813) AND A PORTION OF THIS SIZE FRACTION ENDS UP IN THE FEED TO THE DENSE MEDIUM CIRCUIT. IT IS ASSUMED THAT 10P OF THE COAL LESS THAN 100 MESH IN SIZE IS YIELDED AS BLACKWATER DISCHARGE FROM THIS CIRCUIT. HENCE, SUSPENDED SOLIDS ARE GENERATED AT A RATE OF 41 T/1.0E12 BTU FROM THE DENSE MEDIUM CIRCUIT.
OTHER ELEMENTS WILL ALSO BE CONTAINED IN THE DISCHARGE, BUT DATA HAS NOT BEEN FOUND.

1821

A PORTION OF THE COAL LESS THAN 100 MESH IN SIZE ENDS UP IN THE FEED TO THE CONCENTRATING TABLE CIRCUIT (1P OF THE RAW CRUSHED COAL IS LESS THAN 100 MESH IN SIZE, FOOTNOTE 1820). IT IS ASSUMED THAT 10P OF THE COAL LESS THAN 100 MESH IN SIZE IS DISCHARGED FROM THIS CIRCUIT AS BLACKWATER. HENCE, SUSPENDED SOLIDS ARE GENERATED AT A RATE OF 41 T/1.0E12 BTU. OTHER ELEMENTS WILL ALSO BE CONTAINED IN THE DISCHARGE, BUT DATA HAS NOT BEEN FOUND.

1822

THE COAL LESS THAN 28 MESH IN SIZE IS FED TO THE FROTH FLOTATION CIRCUIT. IT IS ASSUMED THAT 30P OF THE COAL LESS THAN 100 MESH IN SIZE IS DISCHARGED FROM THIS CIRCUIT AS BLACKWATER. THUS, SUSPENDED SOLIDS ARE GENERATED AT A RATE OF 123 T/1.0E12 BTU. OTHER ELEMENTS WILL ALSO BE CONTAINED IN THE DISCHARGE, BUT DATA HAS NOT BEEN FOUND.

1823

THE CALORIC CONTENT OF THE COAL FEED IS 13000 BTU/LB (FOOTNOTE 1047) AND COKE HAS A HEAT VALUE OF 24.8E6 BTU/T (1042,117). ON THE AVERAGE 1.45 AND 1.67 T OF COAL ARE UTILIZED TO PRODUCE A T OF COKE IN SLOT AND BEEHIVE OVENS, RESPECTIVELY (FOOTNOTE 1047 AND 1048). HENCE, THE EFFICIENCY (TOTAL HEAT VALUE OF COAL FEED DIVIDED BY THE TOTAL HEAT VALUE OF THE COKE PRODUCED) IS 66.8P FOR SLOT OVENS AND 58.1P FOR BEEHIVE OVENS.

1824

A CRUSHER OPERATING AT 275 T/HR AND CRUSHING TO A TOPSIZE OF 1.5 IN. REQUIRES A 140 HP MOTOR (1014,7-14). THUS, 1.56E4 KWH OF ENERGY ARE UTILIZED TO CRUSH 1.0E12 BTU EQUIVALENT T OF COAL. THE ENERGY CONSUMED IS EQUAL TO 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER UTILIZATION OR 1.60E8 BTU.

1825

ENERGY CONSUMPTION AT THE PREPARATION PLANT IS 2.13E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION 1.62E5 KWH ARE ELECTRICAL POWER AND 4.74E8 BTU ARE OIL (ASSUMING ALL FUEL PURCHASED TO BE OIL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER CONSUMPTION TO THE FUEL UTILIZATION (1064,12A-16,39).
SINCE THE DISTINCTION BETWEEN THE TYPES OF PREPARATION PLANTS COULD NOT BE MADE IN THE DATA, THE POWER CONSUMPTION DETERMINED ABOVE IS ASSUMED FOR BOTH STEAM AND METALLURGICAL COAL PREPARATION PLANTS.

1826

THE COSTS FOR A 2 MMT/YR ROOM AND PILLAR DEEP MINING OPERATION UTILIZING A CONTINUOUS MINER,RAIL CARS FOR HAULAGE TO TIPPLE AND WORKING A 6 FT SEAM AT 70 PC EFFICIENCY,ARE ESTIMATED AS FOLLOWS (1079)

CAPITAL EXPENSE $17,700,000

	$/T	$/1.0E12 BTU IN
OPERATING EXPENSE	5.89	137,600
FIXED COST (10 PC OF CAPITAL EXPENSE)	0.89	20,800
TOTAL	6.78	158,400

FTN. 1827-

THESE ARE THE ONLY COST FIGURES THAT COULD BE LOCATED. A PUB- 1599
LICATION ON COST ANALYSIS FOR UNDERGROUND MINING WILL BE 1699
RELEASED BY THE BUR. OF MINES AROUND OCTOBER 1973. IT SHOULD 1799
BE NOTED THAT THE ABOVE COSTS INCLUDE HAULAGE FROM FACE TO 1899
TIPPLE. ALSO, THE EFFICIENCY AND SEAM THICKNESS ARE NOT THE 1999
SAME AS WERE USED TO DETERMINE THE ENVIRONMENTAL IMPACTS. 2099
NOTE, HOWEVER, THAT THE $/1.0E12 BTU IN CALCULATION USES A 2199
57 PERCENT PRIMARY EFFICIENCY SO AS TO BE CONSISTENT WITH THE 2299
OTHER DATA. 2399

1827 199

THE EXPENSE INCURRED FOR ELECTRICAL POWER IN ROOM AND PILLAR 299
MINING IS ESTIMATED TO BE $0.17/T AT $0.01/KWH (1079). THUS, 399
THE ENERGY REQUIREMENT FOR AN UNDERGROUND MINING OPERATION IS 499
6.97E5 KWH/1.0E12 BTU EQUIVALENT T EXTRACTED, AND THE REAL 599
ENERGY CONSUMPTION IS 7.14E9 BTU/1.0E12 BTU OUT (3 TIMES THE 699
BTU EQUIVALENT OF THE ENERGY REQUIREMENT). ON A 1.0E12 BTU 799
IN BASIS THIS IS 4.07E09 BTU. THE ENERGY CONSUMPTION FOR A 899
LONGWALL MINING OPERATION IS ABOUT 10 PC LESS THAN THE ENERGY 999
USED IN A ROOM AND PILLAR MINE (1079). THUS, FOR EVERY 1.0E12 1099
BTU EQUIVALENT T OF COAL EXTRACTED, 6.27E5 KWH OR 6.42E9 BTU 1199
OF ENERGY ARE CONSUMED. ON A 1.0E12 BTU IN BASIS THIS BECOMES 1299
5.46E09 BTU. 1399

		CONTROLLED FUEL	CONTROLLED REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		COAL	NATIONAL	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)												AIR POLLUTANTS			
		ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12} BTU	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBON
1	MINE	EXTRACTION																	
2	UNMT	UNDERGROUND																	
3	LONG	LONG WALL		0.00+00 1 1117	7.68+01 4 1117	0000	0000	2.64+01 2 1117	7.64+01 4	3.94-01 2 1117	0000	2.68+01 4	0000	0.00+00 1 0007	0000	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1
4	ROOM	ROOM & PILLAR		0.00+00 1 1117	9.70+01 4 1117	0000	0000	1.91+01 2 1117	1.91+01 4	2.85+01 2 1117	0000	1.94+01 4	0000	0.00+00 1 0007	0000	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1
5	AUGR	AUGER		0.00+00 1 1112	6.22+01 3 1112	0000	0000	9.23+00 2 1112	9.23+00 3	1.44+01 2 1112	0000	9.57+00 3	0000	0.00+00 1 0007	0000	4.04-02 5 1015	1.15+00 5 1015	6.40-02 5 1015	1.15-01 5
6	SURF	SURFACE																	
7	STRP	<15° SLOPE		0.00+00 1 1110	7.46+01 3 1110	0000	0000	1.48+01 3 1110	1.48+01 3	2.54+01 2 1110	0000	1.51+01 3	0000	0.00+00 1 0007	0000	4.53-02 5 1009	1.23+00 5 1009	6.50-02 5 1009	1.23-01 5
8	STRP	>15° SLOPE		0.00+00 1 1108	7.94+01 3 1108	0000	0000	1.60+01 3 1108	1.60+01 3	2.51+01 2 1108	0000	1.63+01 3	0000	0.00+00 1 0007	0000	6.00-02 5 1013	1.96+00 5 1013	1.41-01 5 1013	1.96-01 5
9	TRANS	TRANSPORTATION																	
10	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0.00+00 3 1135	0000	0.00+00 3	0000	0000	0000	2.30-03 5 1003	2.56-01 5 1003	6.77-02 5 1003	6.56-02 5
11	CONV	CONVEYOR		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1017	0.00+00 1 1017	0.00+00 1 1017	0.00+00 1
12	MONR	MONORAIL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1043	0.00+00 2 1043	0.00+00 2 1043	0.00+00 2
13	PROC	PREPARATION																	
14	BREAK	PRIMARY BREAKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000	0000	
15	BCLEA	BOWL CLEANING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000	0000	
16	RSIZE	RAW COAL SIZING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000	0000	
17	DMEDC	DENSE MEDIA (COARSE)		0000	0000	0000	0000	0000	0000	4.10+01 4 1020	0000	4.10+01 4	0000	0.00+00 1 0007	0000	0000	0000	0000	
18	TABLE	TABLES (INTERMEDIATE)		0000	0000	0000	0000	0000	0000	4.10+01 4 1021	0000	4.10+01 4	0000	0.00+00 1 0007	0000	0000	0000	0000	
19	FROTH	FROTH FLOTATION (FINES)		0000	0000	0000	0000	0000	0000	1.23+02 4 1022	0000	1.23+02 4	0000	0.00+00 1 0007	0000	0000	0000	0000	
20	THERM	THERMAL DRYING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.27+02 3 1002	2.87+00 2 1002	7.25-01 2 1002	
21	MIXING	MIXING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	
22																			
23	BREAK	BREAKING & SIZING		0000	0000	0000	0000	0.00+00 2 1078	0.00+00 2	0.00+00 2 1078	0000	0.00+00 2	0000	0.00+00 1 0007	0000	0.00+00 2 1077	0000	0000	
24	STEAM	STEAM COAL PLANT		0.00+00 2 1130	0000	0000	0000	0.00+00 3 1130	0.00+00 3	5.14+00 4 1130	0000	5.14+00 4	0000	0.00+00 1 0007	0000	0.00+00 3 1129	0.00+00 3 1129	0.00+00 3 1129	0.00+00 3
25	METLL	METALLURG. COAL PLANT		0.00+00 2 1124	0000	0000	0000	0.00+00 3 1124	0.00+00 3	3.11+01 4 1124	0000	3.11+01 4	0000	0.00+00 1 0007	0000	6.15-01 2 1123	1.15+00 3 1123	9.67-03 3 1123	0.00+00 2
26	TRANS	DISTRIBUTION																	
27	TRUCK	UNIT TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.77+01 4 1005	1.00+00 3 1005	3.35+00 3 1005	1.00+00
28	MIXT	MIXED TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.10-01 4 1007	1.00+00 3 1007	2.00+00 3 1007	2.00+00 3
29	BARGE	BULK BARGE		0000	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1.74-01 4 1006	6.50-01 3 1006	7.16-01 3 1006	4.45-01 3
30	PIPE	PUMPING SLURRY		0.00+00 1 1024	0.00+00 1 1024	0.00+00 1 1024	0.00+00 1 1024	0.00+00 1	0.00+00 1	0.00+00 1 1024	0.00+00 1 1024	0.00+00 1	0.00+00 1 1024	0.00+00 1 1024	0.00+00 1 1024	0000	0000	0000	
31	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.64+01 4 1000	1.22+00 4 1000	8.81-02 4 1000	1.22-01 4
32	CONV	CONVEYORS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1017	0000	0000	
33	STORA	STORAGE																	
34	AGRND	ABOVE GROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000	0000	
35	UGRND	UNDERGROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000	0000	
36	BLOB	BLOB OR BIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
37	CONVR	CONVERSION																	
38	COKE	COKE PRODUCTION																	
39	SLOT	SLOT OVENS		0000	0000	0000	0000	3.80+00 3 1120	1.60+00 4	0.00+00 2 1030	3.71-03 3 1120	3.20+00 4	1.30+01 4 1120	0000	0.00+00 1 1030	1.02+01 3 1119	7.79-01 3 1020	1.05-02 3 1020	0.31+01 3
40	BEEH	BEEHIVES		0000	0000	0000	0000	1.61+00 2 1030	1.61+00 2	8.40+02 2 1030	1.17-01 2 1030	1.03+01 2	7.47-01 2 1030	0000	0.00+00 1 1030	3.00+03 3 1020	0.00+00 3 1020	0.00+00 3 1020	1.50+02 3
41																			
42																			
43																			
44																			
45																			
46																			
47																			
48																			
49																			

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/10^{12} BTU)							SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	OCCUPATIONAL HEALTH			POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	COST (DOLLARS/10^{12} BTU)			
PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL			DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU				FIXED COST	OPERATING COST	TOTAL COST	ROW
																		1
									1.25-03 1 1023	5.76-01 1 1023	3.11+01 1 1023							2
0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	8.91+02 3 1102	2.00+02 2 1116	0000	0000	0000	1079	0.00-01 1 1000	5.68+09 3 1101	0000	0000	0000	3
0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	5.97+02 3 1102	1.27+02 2 1116	0000	0000	0000	1079	5.70-01 1 1001	6.20+09 3 1101	2.23+04 4 1100	1.41+05 4 1100	1.70+05 3	4
6.04-02 5 1018	1.15+00 5 1018	8.40-02 5 1018	1.15-01 5 1018	7.00-01 5 1018	1.87-02 5 1018	2.11+00 5	6.15+04 3 1114	1.50+01 3 1113	2.00-[illegible] 2 1023	9.25+02 3 1023	1.68+00 3 1023	1000	4.00-01 1 1001	1.08+09 5 1110	5.75+03 3 1110	3.22+04 3 1110	3.80+04 3	5
									3.32-03 1 1023	1.41-01 3 1023	3.40+00 1 1023							6
6.32-02 5 1000	[illegible] 5 1000	0.00-00 5 1000	1.20-02 5 1000	7.40-01 5 1000	3.00-02 5 1000	2.30+00 5	8.73-02 3 1100	1.37+01 2 1107	0000	0000	0000	1001	0.14-01 1 1000	0.11+00 5 1111	5.41+04 3 1100	7.58+04 3 1100	1.10+05 3	7
0.90-02 5 1013	1.16+00 5 1013	1.43-01 5 1013	1.96-01 5 1013	1.18+00 5 1013	3.10-02 5 1013	3.58+00 5	6.18+02 3 1104	2.00+01 2 1103	0000	0000	0000	1001	0.00-01 1 1000	1.08+10 5 1114	1.76+06 3 1105	3.50+05 3 1105	1.68+05 3	8
									2.00-01 1 1030	1.10-01 1 1030	9.73+00 1 1030							9
2.30-02 5 1003	0.50-01 5 1003	4.77-02 5 1003	0.50-02 5 1003	4.00-01 5 1003	1.07-02 5 1003	1.20+00 5	0000	4.15-01 3 1137	0000	0000	0000	1002	1.00+00 1 1000	4.93+08 5 1002	2.53+03 3 1135	8.51+03 3 1040	9.02+03 3	10
0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1	0000	0.00+00 2 1012	0000	0000	0000	1002	1.00+00 1 1000	2.20+08 4 1000	4.60+02 3 1040	1.35+03 3 1040	1.81+03 3	11
0.00+00 2 1002	0.00+00 2 1002	0.00+00 2 1002	0.00+00 2 1002	0.00+00 2 1002	0.00+00 2 1002	0.00+00 2	0000	0.00+00 2 1002	0000	0000	0000	1002	1.00+00 1 1000	0210	0000	0000	0000	12
									6.30-04 1 1011	3.36-03 3 1011	1.03+00 1 1011							13
0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 1 0007	0000	0000	0000	0000	1002	1.00+00 1 1007	1.00+00 2 1014	0000	0000	0000	14
0.00+00 2 1009	0000	0000	0000	0000	0000	0.00+00 2 0007	2.68+00 4 1035	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	0000	0000	0000	15
0.00+00 2 1009	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 1 0007	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	0000	0000	0000	16
0000	0000	0000	0000	0000	0000	0000	8.85-03 3 1017	0000	0000	0000	0000	1002	7.00-01 2 1005	0000	0000	0000	0000	17
0000	0000	0000	0000	0000	0000	0000	9.76+03 3 1018	0000	0000	0000	0000	1002	9.50-01 2 1005	0000	0000	0000	0000	18
0000	0000	0000	0000	0000	0000	0000	6.20+03 3 1018	0000	0000	0000	0000	1002	8.50-01 2 1005	0000	0000	0000	0000	19
1.27+02 3 1002	2.67+00 2 1002	2.29-01 2 1002	0000	0000	0000	1.30-02 3	0.00+00 1 1025	0000	0000	0000	0000	1002	8.90-01 2 1000	7.56-08 3 1011	1.30+03 2 1010	5.40+03 2 1010	4.70+03 2	20
0.00+00 1 0007	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	0000	0000	0000	21
																		22
0.00+00 2 1077	0000	0000	0000	0000	0000	0.00+00 2	2.46+00 4 1033	7.20-01 4 1012	0000	0000	0000	1002	1.00+00 1 1000	1.00+00 4 1000	3.00+02 4 1070	1.00+03 4 1070	2.35+03 4	23
0.00+00 3 1129	[illegible] 3 1129	0.00+00 3 1129	0.00+00 3 1129	0.00+00 3 1129	0.00+00 3 1129	0.00+00 3	3.75+03 3 1131	2.09+00 3 1138	0000	0000	0000	1002	0.00-01 2 1000	2.26+09 4 1133	4.10+02 3 1132	1.03+04 3 1132	1.45+04 3	24
8.33-01 3 1123	1.16+00 3 1123	8.47-02 3 1123	0.00+00 3 1123	0.00+00 3 1123	0.00+00 3 1123	2.08+00 3	8.11+03 3 1125	2.34+00 3 1128	0000	0000	0000	1002	0.52-01 2 1000	2.77+09 4 1127	8.16+01 3 1126	1.55+04 3 1126	1.34+04 3	25
																		26
1.77+01 4 1005	3.00+10 3 1005	3.35+00 3 1005	2.04+00 3 1005	3.01+00 3 1005	5.07-01 3 1005	1.16-01 3	0000	5.39+01 2 1037	8.10-02 2 1033	5.83-01 2 1033	5.95-01 2 1033	1002	1.00-00 3 1001	1.43+10 4 1002	5.10+03 3 1052	7.90+04 3 1052	9.40+04 2 1045	27
3.38-01 4 1007	1.05+00 5 1007	2.03+00 5 1007	2.00+00 5 1007	2.85+00 5 1007	4.46-01 5 1007	4.49-01 5	0000	3.30+01 2 1037	8.10-02 2 1033	5.83-01 2 1033	5.95+01 2 1033	1002	0.92-01 2 1001	1.12+10 5 1006	9.24+03 3 1052	1.45+05 3 1052	1.54+05 2 1046	28
1.74-01 4 1000	0.50-01 3 1000	7.15-01 3 1000	4.47-01 3 1000	5.90-01 3 1000	3.44-02 3 1000	1.00-01 3	0000	0000	1.83-03 2 1003	3.21-03 2 1003	3.43-01 4 1003	1002	1.00-00 3 1001	7.70+09 3 1000	4.85+03 3 1051	3.56+04 3 1051	4.04+04 2	29
0000	0000	0000	0000	0000	0000	0000	0000	1.00+01 2 1017	0.00+00 1 0007	0.00+00 1 000	0.00+00 1 0007	1002	0.00-01 2 1002	7.00+09 2 1000	6.05+04 2 1055	2.00+04 2 1055	8.05+04 2	30
1.04+01 4 1000	1.22+00 4 1000	0.01-02 4 1000	1.20-01 4 1000	7.43-01 4 1000	1.00-02 4 1000	1.00-01 4	0000	1.30+00 3 1010	3.84-03 3 1007	0.00-01 3 1001	6.94+01 3 1001	1002	1.00-00 3 1001	9.17+09 4 1007	1.05+03 3 1007	1.07+04 3 1007	1.80+04 2	31
0.00+00 1 1017	0000	0000	0000	0000	0000	0.00+00 1 0000	0000	5.70-01 2 1054	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	1.00-00 4 1002	3.01+08 4 1000	1.05+04 4 1055	5.10+03 4 1055	1.56+04 4	32
																		33
0000	0000	0000	0000	0000	0000	0000	0000	7.02-01 2 1031	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	1.50+00 5 1000	4.08+02 5 1000	3.30+03 5 1000	3.71+03 5	34
0000	0000	0000	0000	0000	0000	0000	0000	7.02-01 5 1001	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	1.50+00 5 1000	4.08+02 5 1000	3.30+03 5 1000	3.71+03 5	35
0000	0000	0000	0000	0000	0000	0000	0000	3.50-01 2 1032	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.03-01 2 1007	1.50+00 5 1000	1.15+01 5 1000	2.10+03 6 1000	1.41+03 5	36
																		37
																		38
1.02+01 3 1119	7.70-01 3 1020	1.05+02 3 1020	8.51+01 3 1020	2.47+01 3 1020	5.61+00 3 1020	3.30+01 3	1.67+01 3 1111	1.71+00 4 1121	3.00-03 1 1000	0.00-00 1 1000	2.00+01 1 1000	1002	0.00-01 2 1020	0000	0000	0000	4.80+05 4 1120	39
0.00+00 3 1020	0.00+00 3 1020	0.00+00 3 1020	1.00+02 3 1020	1.00+01 3 1020	3.00+01 3 1020	0.11+03 3	0.00+00 1 1020	0.00-01 3 1000	1.77-03 1 1000	0.00-01 1 1000	1.00+00 1 1000	1002	0.81-01 2 1020	0.00+00 1 1000	0000	0000	1.00+05 2 1040	40
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TABLE 2. ENVIRONMENTAL IMPACTS, EFFICIENCY AND COST FOR CONTROLLED NATIONAL COAL SUPPLY

FOOTNOTES FOR TABLE 2

1100

A HYDRATED LIME PROCESS IS UTILIZED FOR TREATMENT OF ACID MINE DRAINAGE. ASSUMING AN ACID LOAD OF 3000 PPM, THE PLANT WILL HAVE TO PROCESS .94 MMG/D OF DRAINAGE FROM ROOM AND PILLAR MINES, AND .87 MMG/D FROM LONGWALL MINES (MINE DRAINAGE POLLUTANT LOADS, FOOTNOTE 1018). THE TOTAL IRON CONCENTRATION IS ABOUT 500 PPM FOR BOTH TYPES OF MINE. FOR THE PURPOSE OF COST ESTIMATION THE PLANT IS ASSUMED TO HAVE A CAPACITY OF TREATING 1 MMG/D. THE ESTIMATED COSTS ARE AS FOLLOWS (1102, 234,236).

	MILLIONS OF DOLLARS	$/1.0E12 BTU IN
CAPITAL EXPENSE (WITH SLUDGE DISPOSAL)	1.40	
OPERATING EXPENSE	0.830	9700
FIXED COST (10 PC OF CAPITAL EXPENSE)	0.140	1640

THE TREATMENT FACILITY IS RELATED TO A MINE PRODUCING 2 MMT/YR OF COAL WITH A CALORIC CONTENT OF 12,180 BTU/LB.
IT SHOULD BE NOTED THAT A LIMESTONE-LIME TREATMENT FACILITY MAY BE MORE ECONOMICAL AND EFFICIENT, BUT COST ESTIMATES FOR SUCH A PLANT HAVE NOT BEEN DEVELOPED (1105). ALSO, DRAINAGE VARIES SUBSTANTIALLY FROM MINE TO MINE AND THEREFORE THE MOST EFFECTIVE METHOD FOR TREATING MINE DRAINAGE WILL NOT BE THE SAME FOR EACH MINE.
QUICKSETTING DOUBLE BULKHEAD HYDRAULIC SEALS ARE EMPLOYED TO SEAL THE ADIT AT THE CLOSING OF THE MINE (1102,80/82). DUE TO FRACTURES THAT USUALLY DEVELOP IN THE STRATA SURROUNDING THE MINE ENTRANCE, THE BULKHEAD ITSELF WILL NOT SUFFICIENTLY PREVENT ACID DRAINAGE. HENCE, CURTAIN GROUTING IS ALSO EMPLOYED. THE COSTS INCURRED FOR MINE SEALING ARE ADDED TO OTHER ANNUAL EXPENSES AS FIXED COST, AND ARE AS FOLLOWS

	$	$/1.0E12 BTU IN
CAPITAL EXPENSE		
MINE SEAL (1102,94)	9600	
CURTAIN GROUTING (1102,95)	11100	
ANNUAL EXPENSE		
FIXED COST (10 PC OF CAPITAL EXPENSE)	2070	24.2

THE COSTS GIVEN HERE ARE IN ADDITION TO THE COSTS SHOWN IN FOOTNOTE 1826 FOR ROOM AND PILLAR MINING.

1101

THE AVERAGE ANNUAL POWER EXPENSE FOR THE HYDRATED LIME SYSTEMS UTILIZED IN OPERATION YELLOWBOY WAS ABOUT $1640J/MMG/D (1102, 231). THUS AT A COST OF $0.015/KWH THE ENERGY REQUIREMENT TO OPERATE A 1 MMG/D HYDRATED LIME PROCESS (ASSOCIATED WITH A 2E06 TON/YR MINE) IS 1.115E10 BTU/YR. THUS 2.28E08 BTU/YR OF ENERGY IS REQUIRED TO TREAT THE OUTPUT ASSOCIATED WITH A 1.0E12 BTU/YR MINE. ON A 1.0E12 BTU IN BASIS THIS AMOUNTS TO

1.31E08 BTU FOR ROOM AND PILLAR MINES AND 1.95E8 BTU FOR 999
LONGWALL MINES. THIS ENERGY CONSUMPTION IS IN ADDITION TO 1099
THE POWER UTILIZED DURING NORMAL MINING OPERATIONS (FOOTNOTE 1199
1827). 1299

1102 199

SOLID WASTE PRODUCTION FOR A 1 MMG/D HYDRATED LIME PLANT TREATING 299
A DRAINAGE COMPOSED OF 3000 PPM ACIDITY IS ABOUT 33 AC-FT/YR 399
(1102,233). ASSUMING A PRECIPITATE DENSITY OF 71 LBS/CF 499
(1114,288) SOLID WASTE IS GENERATED AT A RATE OF 51000 T/YR 599
FOR A 2MM TPY MINE. ON A 1.0E12 BTU IN BASIS THIS BECOMES 889 699
TON FOR LONGWALL MINING AND 596 TON FOR ROOM AND PILLAR. THIS 799
IS IN ADDITION TO THE SOLID WASTE PRODUCTION OF FOOTNOTE 1021. 899
IT SHOULD BE NOTED THAT, IN SOME CASES, THE SLUDGE PRODUCED 999
FROM THE TREATMENT FACILITY COULD BE DISPOSED INTO ABANDONED 1099
DEEP MINES (1103). THIS WOULD ELIMINATE LAND USE FOR DISPOSAL 1199
AND MAY POSSIBLY REDUCE SUBSIDENCE. CONDITIONS PERMITING, THIS 1299
APPEARS TO BE AN EFFECTIVE MEANS FOR DISPOSAL OF THE SLUDGE. 1399

1103 199

FOR CONTOUR MINING (SLOPES GREATER THAN 15 DEGREES) IT IS ASSUMED 299
THAT THE MODIFIED BLOCK CUT METHOD IS EMPLOYED. 399
THE THICKNESS OF THE SEAM IS 3.8 FT, THUS 6.12 AC OF LAND ARE 499
OVERTURNED PER 1.0E12 BTU IN. AT THE SAME TIME 1776 FT OF 599
BENCH ARE CREATED (FOOTNOTE 1037). ASSUMING STRIPS OF LAND 699
50 FT WIDE ARE AFFECTED FOR THE DIVERSION DITCH AND FOR THE 799
STORAGE OF TOP SOIL ON THE OUTSLOPE, AN ADDITIONAL 4.08 AC 899
ARE DISTURBED FOR EACH 1.0E12 BTU IN. 999
THE SOLID WASTE GENERATED DURING THE BOX CUT (FOOTNOTE 1104) 1099
IS DISPOSED OF BY THE PARALLEL SLOPE METHOD. THE ANGLE AT THE 1199
TOE OF FILL IS 35 DEGREES. IN A PILE 40 FT HIGH, THE TOE 1299
REACHES 400 FT DOWNSLOPE FROM THE OUTCROP. HENCE, 1.69 AC 1399
(FIXED LAND USE) ARE DISTURBED. 1499
IN TIME AVERAGING THE LAND IMPACTS,CONSIDERATION MUST BE GIVEN 1599
TO THE EFFECTS OF RECLAMATION, WHICH IN THIS CASE IMPLIES 1699
CONTOUR BACKFILLING, SEED BED PREPARATION, TERRACING AND 1799
REVEGETATION. THE CRITERION FOR REVEGATATION IS THE ESTABLISH- 1899
MENT OF AN HERBACEOUS COVER SUFFICIENT TO STABILIZE THE SUR- 1999
FACE AGAINST EROSION. OTHER RECLAMATION PRACTICES, E.G., 2099
REFORESTATION, CAN BE OCCURING SIMULTANEOUSLY. 2199
IN APPALACHIA, WHERE MOST CONTOUR MINING IS PRACTICED, 3 2299
GROWING SEASONS ARE REQUIRED TO ESTABLISH A 95 PC COVER OF 2399
GRASS AND LEGUMES (1101). EMPLOYING THIS TIME SCALE AS A 2499
STANDARD, THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT OF THE 2599
VARIABLE LAND USE (10.2 AC/1.0E12 BTU) IS 28.8 AC-YR/1.0E12 2699
BTU IN. THE LAND IMPACT OF THE RECLAIMED WASTE IS NEGLIGIBLE 2799
RELATIVE TO THE OVERALL LAND IMPACTED. 2899
AN ADDITIONAL 3.08 AC OF LAND IS UTILIZED FOR A SETTLING POND 2999
10 FT IN DEPTH WITH A CAPACITY OF 10 MMGAL. THE TREATMENT 3099
FACILITY (SODA ASH) TO NEUTRALIZE THE ACID RUNOFF OCCUPIES 3199
VERY LITTLE LAND (FOOTNOTE 1105). THUS, FOR A PRODUCTION 3299
CAPACITY OF 2 MMT/YR, THE LAND IMPACT IS 0.050 AC-YR/1.0E12 3399
BTU IN. 3499
THE TOTAL LAND IMPACT IS THEREFORE, 28.9 AC-YR/1.0E12 BTU IN. 3599

1104 199

FOR THE MODIFIED BLOCK CUT MINING TECHNIQUE, SOLID WASTE IS PRO- 299
DUCED ONLY DURING THE BOX CUT. HENCE, FOR A SLOPE ANGLE OF 399
20 DEGREES, A BENCH WIDTH OF 150 FT, A 15 FT RIM OF BLOSSOM 499
COAL, AND A BOX CUT OF 600 FT IN LENGTH, 0.148 MMT OR 96.8 599
T/1.0E12 BTU IN OF SOLID WASTE IS PRODUCED (SUBSEQUENT TO THE 699
BOX CUT 50 MMT OF COAL IS REMOVED OVER A 25 YR PERIOD). THE 799

LENGTH OF THE BOX CUT IS BASED ON 250 FT LONG SECOND AND
THIRD CUTS (1104) AND ALLOWS FOR EXPANSION.
THE SLUDGE PRODUCED FROM THE SODA ASH TREATMENT PROCESS IS
ABOUT 4P BY VOLUME (EXTRAPOLATED FROM INFORMATION ON CONSOL.
COAL CO. PROCESS, REF. 1106). THUS FOR THE TREATMENT OF 0.5
MMG/D (FOOTNOTE 1106), THE SOLID WASTE IS GENERATED AT A RATE
OF 321 T/1.0E12 BTU IN.

1105

ACID DRAINAGE FROM CONTOUR MINES IS NEUTRALIZED BY A SODA ASH
TREATMENT PROCESS. THIS PROCESS IS IN MOST COMMON USAGE FOR
MINES WITH SMALL DRAINAGE (1105). THE FACILITY DESCRIBED HERE
IS ONE THAT IS UTILIZED BY CONSOLIDATED COAL COMPANY (1106).
THE FACILITY TREATS A DRAINAGE WITH ABOUT 300 PPM ACIDITY AND
ALL FIGURES HAVE BEEN SCALED UP LINEARLY FOR TREATING A 0.5
MMG/D WITH AN ACIDITY CONCENTRATION OF 800 PPM (MINE DRAINAGE
POLLUTANT LOAD, FOOTNOTE 1041). THE COSTS (ASSOCIATED WITH
A 2E06 TCH/YR MINE) ARE AS FOLLOWS

	1.0E3 $	
CAPITAL EXPENSE	62.0	
ANNUAL EXPENSE	1.0E3 $/YR	$/1.0E12 BTU IN
REPAIR, MAINTENANCE, ETC. ($.11/1000 GAL)	13.2	
POWER ($.1/1000 GAL)	12.0	
SODA ASH (6.7 LBS/1000 GAL, $125/T)	52.8	
SUBTOTAL	78.0	1280
FIXED COST (10 PC OF CAPITAL EXPENSE)	6.2	102

THE COSTS OF MINING BY THE MODIFIED BLOCK CUT TECHNIQUE,
INCLUDING RECLAMATION COSTS, ARE AS FOLLOWS (1028,29)

	$/T	$/1.0E12 BTU IN
OPERATING EXPENSE	3.92	128,600
FIXED COST	.54	17,700

THE ABOVE ESTIMATES ARE BASED ON A MINING OPERATION WITH A
PRODUCTION RATE OF 0.25 MMT/YR, A SEAM THICKNESS OF 3 FT AND
A HIGHWALL 55 FT HIGH. THESE ARE NOT THE SAME SPECIFICATIONS
FOR WHICH THE ENVIRONMENTAL IMPACTS WERE DETERMINED BUT ARE
THE ONLY COST DATA AVAILABLE. IT SHOULD BE NOTED THAT THE
COST OF PRODUCTION BY STRIP MINING IN TERMS OF UNIT ENERGY
DISPLAYS SENSITIVITY MAINLY TO THE ECONOMIES OF SCALE (1041,3)
NOTE THAT THE MINING METHOD USED IN THE CONTROLLED CASE
DIFFERS FROM THAT USED IN THE UNCONTROLLED CASE.

1106

SODIUM BASED ALKALIS EFFECTIVELY REMOVE ACIDITY, IRON, ALUMINUM
AND OTHER OXIDES, BUT WILL NOT REMOVE THE SULFATES AS SODIUM
SULFATE IS A HIGHLY SOLUBLE SALT (1102,130). THIS HAS BEEN
VERIFIED IN THE MEASUREMENTS OF THE EFFLUENTS FROM A SODA ASH
FACILITY, WHERE THE PH WAS RAISED TO ABOUT 7, THE ACIDITY
REDUCED TO 0, THE ALKALINITY TO 88 PPM AND THE IRON DOWN TO
0.9 PPM (1106). THE DISCHARGE TO NATURAL DRAINAGE IS ASSUMED
TO BE AS FOLLOWS (MINE DRAINAGE POLLUTANT LOAD, FOOTNOTE 1041,
ALSO SEE FOOTNOTE 1105). FACILITY OPERATES 245 D/YR:

FTN. 1107-1109

	PPM	T/1.0E12 BTU IN
ACIDITY	0	0
ALKALINITY	88.0	0.734
IRON	0.9	0.00753
MANGANESE	1.5	0.0126
ALUMINUM	0.5	0.00418
SULFATE		13.1
SODIUM		2.92
SUBTOTAL		16.0
SUSPENDED SOLIDS	30.0	0.251

THE SUSPENDED SOLIDS ARE ASSUMED TO BE IN COMPLIANCE WITH THE GUIDELINES ESTABLISHED BY EPA (1112).

1107

FOR AREA STRIPPING (SLOPE LESS THAN 15 DEGREES) 4.47 AC OF LAND ARE OVERTURNED PER 1.0E12 BTU IN AND 0.133 AC-YR IS OCCUPIED BY THE SOLID WASTE PILE (FOOTNOTE 1001). WITH RECLAMATION, THE LAND IS RESTORED TO THE ORIGINAL CONTOUR, GRADED TO MINIMIZE EROSION AND REVEGETATED. FOR THE PURPOSES OF QUANTIFICATION OF THE IMPACTS, STABILIZATION BY A HERBACEOUS COVER IS THE CRITERION FOR DETERMINING RECLAMATION.
IN THE WEST, UPWARDS OF 5 YRS ARE REQUIRED TO ESTABLISH A VEGETAL COVER (IT MAY NOT AT ALL BE POSSIBLE TO REESTABLISH A STABLE COVER IN THE ARID AND SEMI-ARID REGIONS) AND UPWARDS OF 2 YRS ARE REQUIRED IN APPALACHIA AND THE CENTRAL REGION (1100)
SINCE MOST OF THE PRODUCTION (90P) OCCURS IN REGIONS OTHER THAN THE WEST, IT IS ASSUMED THAT 3 YRS ARE REQUIRED TO REESTABLISH AN HERBACEOUS COVER TO STABILIZE THE SURFACE AGAINST EROSION (FOOTNOTE 1103). HENCE, THE TIME AVERAGED (OVER 25 YEARS) LAND IMPACT IS 12.6 AC-YR/1.0E12 BTU IN.
ANOTHER 0.051 AC-YR/1.0E12 BTU IN IS UTILIZED FOR THE SODA ASH TREATMENT FACILITY (FOOTNOTE 1103).

1108

IN THE MINING OPERATION SOLID WASTE IS GENERATED ONLY FROM THE BOX CUT. THE WASTE AMOUNTS TO 347 T/1.0E12 BTU IN (FOOTNOTE 1009). THE SLUDGE PRODUCED FROM THE SODA ASH TREATMENT FACILITY IS ABOUT 4P BY VOLUME (EXTRAPOLATED FROM INFORMATION ON CONSOL. COAL CO. PROCESS, REF. 1106). THUS FOR THE TREATMENT OF 0.5 MMG/DAY THE SOLID WASTE IS GENERATED AT A RATE OF 325 T/1.0E12 BTU IN (FOOTNOTE 1104).

1109

A SODA ASH TREATMENT PROCESS IS UTILIZED FOR TREATING THE ACID DRAINAGE (FOOTNOTE 1105). THE FACILITY TREATS 0.5 MMG/DAY (ASSOCIATED WITH A 2.0E06 TON/YR MINE) WITH AN ACID CONCENTRATION OF 700 PPM. THE COST FIGURES ARE AS FOLLOWS

CAPITAL EXPENSES $62,000

ANNUAL EXPENSES	$/YR	$/1.0E12 BTU IN
REPAIR, MAINT., ETC. ($.11/1000 GAL)	$13,200	
POWER ($.1/1000 GAL)	12,000	
SODA ASH ($125/T, 5.9LBS/1000 GAL)	46,200	
TOTAL	71,400	1190
FIXED COST (10P OF CAPITAL EXPENSE)	6,200	103
GRAND TOTAL	79,600	1290

THE CAPITAL COST FIGURES INCLUDE THE COSTS OF A 10 MMG LAGOON, THE TREATMENT FACILITY, PIPES, ETC. THE LAND IS ASSUMED TO BE AVAILABLE.

IN CASES WHERE AREA MINES ARE BEING WORKED BELOW THE WATER TABLE,A LARGER TREATMENT FACILITY MAY BE REQUIRED. DUE TO THE HIGH COST OF SODA ASH,A LIME OR LIMESTONE PROCESS WOULD THEN BE UTILIZED.

GRADING THE SPOIL BANKS TO THE ORIGINAL CONTOUR AND REDUCING THE SLOPES OF THE HIGHWALL INCURS AN ADDITIONAL EXPENSE OF ABOUT $500/AC ($400 TO REDUCE THE BANKS TO A 5/1 SLOPE (1108, 32). COMPLETE LEVELING COSTS AN ADDITIONAL $100 (1109)). THE COST FOR RECLAIMING THE TOPSOIL IS APPROXIMATELY $400/AC IF THE WORK IS DONE WITH SCRAPERS AND STOCKPILED ONCE (1100). THE COST FOR REVEGETATION IS ABOUT $300/AC (1110,6). HENCE, THE TOTAL COST OF RECLAMATION AMOUNTS TO $1200/AC or $5370/ 1.0E12 BTU IN, WHICH INCLUDES THE COST FOR RECLAIMING THE SOLID WASTE PILE (SEE FOOTNOTE 1001).

THE TOTAL COST IN ADDITION TO THE USUAL MINING OPERATION IS $6660/1.0E12 BTU IN (FOOTNOTE 1067).

1110

THE DISCHARGE FROM THE TREATMENT FACILITY TO THE NATURAL DRAINAGE IS ASSUMED TO HAVE THE FOLLOWING COMPOSITION((FOOTNOTE 1020 FOR RAW WASTE LOAD, ALSO FOOTNOTE 1106 AND 1109).

	PPM	T/1.0E12 BTU IN
ACIDITY	0	0
ALKALINITY	88	0.744
IRON	0.8	0.00677
MANGANESE	1.5	0.0127
ALUMINUM	0.5	0.00424
SULFATES		12.2
SODIUM		2.61
TOTAL		14.8
SUSPENDED SOLIDS	30.0	0.254

THE SUSPENDED SOLIDS ARE ASSUMED TO BE IN COMPLIANCE WITH THE GUIDELINES ESTABLISHED BY EPA (1112). THE TREATMENT FACILITY IS ASSUMED TO OPERATE 245 D/YR.

1111

AT $0.015/KWH THE ENERGY CONSUMED BY THE SODA ASH TREATMENT FACILITY IS 8.16E9 BTU (FOOTNOTE 1109) FOR A 2E6 TPY MINE OR 1.36E8 BTU/1.0E12 BTU IN. THE TOPSOIL IS HANDLED BY A SCRAPER AND THE SOIL BANKS ARE LEVELED WITH A BULLDOZER. ASSUMING THE ENERGY CONSUMPTION BY THE DOZER IS CHARACTERISTICALLY SIMILAR TO THAT FOR A SCRAPER, THE ENERGY CONSUMPTION IS AS FOLLOWS (1111,476).

	1.0E9 BTU
TOPSOIL (4750 CY/1.0E12 BTU IN, PERFORMANCE OF 75 CY/HR AND 11.34 GAL/HR)	0.101
RECLAMATION (35600 CY/1.0E12 BTU IN, PERFORMANCE OF 250 CY/HR AND 11.34 GAL/HR)	0.222

THUS, FOR 1.0E12 BTU IN THE TOTAL ENERGY REQUIREMENT FOR CONTROLS IS 4.59E08 BTU AND IS IN ADDITION TO THAT FROM THE USUAL MINING OPERATION (FOOTNOTE 1806).

1112

THE DRAINAGE FROM AUGER MINES HAS BEEN ASSUMED TO THE SAME AS THAT FROM CONTOUR MINES (FOOTNOTE 1019). THUS, A SIMILAR WATER TREATMENT FACILITY IS UTILIZED AND THE EFFLUENT LOADING IS THEREFORE THE SAME (FOOTNOTE 1106). THE TABLE ENTRIES DIFFER BECAUSE OF THE PRIMARY EFFICIENCY DIFFERENCE.

1113

IN AUGER MINING THE BENCH AND SPOIL PILE COVER AN AREA OF 2.71 AC FOR EVERY 1.0E12 BTU IN AND AN ADDITIONAL 1.28 AC/1.0E12 BTU IN ARE AFFECTED BY SUBSIDENCE (FOOTNOTE 1026). RECLAMATION INCLUDES CONTOUR BACKFILLING AND REVEGETATION AS WELL AS PLUGGING THE FIRST 6 FT OF THE AUGER HOLE TO MINIMIZE DRAINAGE PROBLEMS (1051,31). IT IS ASSUMED THAT 3 YRS ARE REQUIRED TO REESTABLISH AN HERBACEOUS COVER TO STABILIZE THE SURFACE (FOOTNOTE 1103). HENCE, THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS 7.64 AC-YR/1.0E12 BTU IN FOR THE BENCH AND SPOIL PILE AND 17.3 AC-YR/1.0E12 BTU IN FOR THE SUBSIDED AREA. AN ADDITIONAL 0.029 AC-YR/1.0E12 BTU IS AFFECTED BY THE SODA ASH TREATMENT FACILITY (FOOTNOTE 1103).

1114

THE SOLID WASTE PRODUCED FROM AUGER MINES IS 41300 T/1.0E12 BTU IN (FOOTNOTE 1070). THE ADDITIONAL SOLID WASTE PRODUCED FROM THE DRAINAGE TREATMENT FACILITY AMOUNTS TO 184 T/1.0E12 BTU IN (FOOTNOTE 1104. THE TREATMENT FACILITY USED AT CONTOUR MINES IS UTILIZED FOR AUGER MINES).

1115

THE COSTS INVOLVED IN OPERATING THE SODA ASH TREATMENT FACILITY ARE AS FOLLOWS (FOOTNOTE 1105), OPERATING EXPENSE, $1280/1.0E 12 BTU IN, FIXED COST, $102/1.0E12 BTU IN.

RECLAMATION COSTS ARE AS FOLLOWS (SEE FOOTNOTE 1026).

	$/AC	$/1.0E12 BTU IN	REFERENCE
CONTOUR BACKFILLING	351	453	(1102,29)
REVEGETATION	400	516	(1102,48)

THE ESTIMATED COST FOR BACKFILLING MAY BE INFLATED SINCE THE DATA ARE FOR RECLAMATION OF ABANDONED MINES. THE DATA WERE UTILIZED BECAUSE THEY APPLY SPECIFICALLY TO PARTS OF THE APPALACHIAN REGION.

RECLAIMING THE TOPSOIL WILL COST ABOUT $400/AC. THIS ASSUMES THAT THE SOIL IS HANDLED ONLY MINIMALLY. STOCKPILING THE SOIL ABOVE THE HIGHWALL WILL MEET THIS REQUIREMENT. THE ADDITIONAL EXPENSE AMOUNTS TO $516/1.0E12 BTU IN.

THE TOTAL INCREMENTAL COST TO THE USUAL AUGERING OPERATION IS $2870/ 1.0E12 BTU IN.

THE NORMAL COST FOR AUGER MINING (FOR A 222,000 T/YR OPERATION) LESS HAULAGE TO TIPPLE AND RECLAMATION IS $3650/1.0E12 BTU IN FOR FIXED COST AND $29400/1.0E12 BTU IN FOR OPERATING COST (REF. 1052 AND FOOTNOTE 1066).

1116

THE ENERGY CONSUMED BY THE SODA ASH TREATMENT FACILITY IS 7.69E7 BTU/1.0E12 BTU IN (FOOTNOTE 1105, AT $0.015/KWH). THE ENERGY UTILIZATION FOR RECLAMATION IS ASSUMED TO BE SIMILAR TO THAT FOR AREA MINES EXCEPT FOR THE LESSER AMOUNT OF MATERIAL HANDLED IN THIS CASE (43% OF THE MATERIAL HANDLED BY AREA MINES). THUS, THE ENERGY CONSUMED IS 0.14E9 BTU/1.0E12 BTU IN (SEE FOOTNOTE 1111). THUS FOR 1.0E12 BTU IN THE ENERGY REQUIREMENT FOR CONTROLS IS 2.17E8 BTU AND IS IN ADDITION TO THAT FROM THE USUAL MINING OPERATION (FOOTNOTE 1010).

1117

IT IS ASSUMED THAT THE EFFLUENTS WILL MEET THE STANDARDS ESTABLISHED BY EPA (1112). IN LIME TREATMENT THE SULFATE LOAD WILL BE REDUCED SINCE THE SOLUBILITY OF CALCIUM SULFATE IS 2000 PPM (1113,24). THE HARDNESS WILL ALSO BE INCREASED. THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	PPM	T/1.0E12 BTU IN ROOM AND PILLAR	LONGWALL
SUSPENDED SOLIDS	30	0.285	0.394
ACIDITY	0	0	0
ALKALINITY	60	0.570	0.788
IRON	4	0.0386	0.0526
MANGANESE	4	0.0386	0.0526
ALUMINUM	1	0.00946	0.0132
CALCIUM SULFATE	2000	19.0	26.3
TOTAL	2009	19.1	26.4

THE ALKALINITY FIGURE WAS OBTAINED FROM DATA IN REF. (1103). THE VOLUME OF DISCHARGE IS ABOUT 85P OF THE INFLOW VOLUME (1103)-OR .80 MMG/D FOR ROOM AND PILLAR MINES AND.74 MMG/D FOR LONGWALL MINES (FOOTNOTE 1100) AND THE PLANT IS ASSUMED TO OPERATE 245 D/YR.

1118

IT IS ASSUMED THAT THE TREATMENT FACILITY WILL REQUIRE A 2MMG RAW WATER STORAGE POND AND A 100MMG SETTLING POND, AND THAT THE LAND IS AVAILABLE (THE COST FOR SLUDGE DISPOSAL IS INCLUDED IN THE COST ESTIMATES, BUT THE SIZE OF THE PONDS ARE NOT STIPULATED). AT A DEPTH OF 10 FT FOR THE RAW WATER POND AND A DEPTH OF 20 FT FOR THE SETTLING POND, 15.5 AC OF LAND ARE REQUIRED. THE TREATMENT PLANT WILL REQUIRE ABOUT 3 AC (1114). THUS, THE TOTAL LAND REQUIRED BY THE TREATMENT FACILITY IS 0.385 AC-YR/1.0E12. ON A 1.0E12 BTU IN BASIS THIS AMOUNTS TO 0.329 AC-YR FOR LONGWALL AND 0.221 AC-YR FOR ROOM AND PILLAR MINING. THIS LAND IMPACT IS ADDITIONAL TO THE LAND USAGE OF FOOTNOTES 1022 AND 1036 FOR ROOM AND PILLAR AND LONGWALL MINING, RESPECTIVELY.

1119

PARTICULATE EMISSIONS FROM BY-PRODUCT COKING OPERATIONS CAN BE REDUCED AS FOLLOWS. CHARGING PARTICULATE EMISSIONS CAN BE VIRTUALLY ELIMINATED BY THE USE OF A PIPELINE CLOSED CHARGING SYSTEM (1117,190). PUSHING PARTICULATE EMISSIONS CAN BE LOWERED BY 99.8P BY THE USE OF A COLLECTING HOOD CONNECTED TO A VENTURI SCRUBBING AND CYCLONE SEPARATOR SYSTEM (1118,14). THE RESULTING PARTICULATE EMISSIONS AMOUNT TO .5232 LB/TON OF COAL COKED (FROM (0002,7-4) AND FOOTNOTE 1028) OR 10.2 TON/1.0 E12 BTU.

1120

(1119) LISTS THE EFFLUENT LIMITATIONS FOR COKE MANUFACTURING BASED ON THE USE OF BEST PRACTICAL CONTROL TECHNOLOGY CURRENTLY AVAILABLE. THE CONTROL TECHNOLOGY USED TO ACHIEVE THESE (TREATMENT LEVEL A) VALUES INCLUDES AMMONIA STILLS, A CYANIDE STRIPPING STILL, RECYCLE OF COOLING EFFLUENTS, A DISSOLVED AIR FLOTATION UNIT, AND A PHENOL BIO-OXIDATION SYSTEM. THE CONTROLLED DISCHARGE LEVEL IS

POLLUTANT	LBS/TON DRY COAL	TON/1.0E12 BTU IN
AMMONIA(N)	.20	3.71
CYANIDE	.005	.0927
PHENOL	.0002	.00371
BOD5	.70	13.0

THE ABOVE NO. ARE BASED ON AN INPUT METALLURGICAL COAL WITH 5 1499
P MOISTURE AND A HEATING VALUE OF 13000 BTU/LB (SEE FOOTNOTE 1599
1034). THE CONTROLLED BOD5 EMISSION GIVEN ABOVE IS BASED ON AN1699
80P REDUCTION OF BOD5 IN THE PHENOL BIO-OXIDIZER (SEE FOOTNOTE1799
1034). 1899

1121 199

BASED ON 100P REMOVAL OF PARTICULATES FROM COKE CHARGING AND 99.8P 299
REMOVAL FROM THE PUSHING OPERATION (SEE FOOTNOTES 1119 AND 399
1028), AN ADDITIONAL 2.099 LB SOLID WASTE/TON COAL COKED IS 499
GENERATED, OR 41.0 TON/1.0E12 BTU. THIS IS ADDED TO THE 599
UNCONTROLLED SOLID WASTE NO.(SEE FOOTNOTE 1029) TO GIVE A 699
TOTAL SOLID WASTE GENERATION OF 58.2 TON/1.0E12 BTU. BASED ON 799
FOOTNOTE 1030 THIS SOLID WASTE OCCUPIES .02 ACRE-YR/1.0E12 899
BTU. THE LAND REQUIRED FOR THE CHARGING AND PUSHING CONTROL 999
SYSTEMS CAN BE A SIGNIFICANT FRACTION OF THE LAND REQUIRED FOR1099
THE COKE BATTERY (1120). IT HAS BEEN ASSUMED THAT THE LAND 1199
REQUIRED FOR CONTROLS AMOUNTS TO 25P OF THE LAND OCCUPIED BY 1299
THE COKE BATTERY. THUS 1.69 ACRE-YR/1.0E12 BTU IS REQUIRED FOR1399
THE BATTERY AND SUPPORTING CONTROLS (SEE FOOTNOTE 1030). THE 1499
TOTAL LAND REQUIREMENT FOR THE COKE BATTERY AND CONTROL SYSTEM1599
THEREFORE IS 1.71 ACRE-YR/1.0E12 BTU. 1699

1122 199

THE TOTAL ANNUAL COST FOR THE CONTROL OF AIR AND WATER EMISSIONS 299
HAS BEEN ESTIMATED TO BE 3P OF THE SELLING PRICE OF COKE FROM 399
(1118,18). NO ADDITIONAL INFORMATION HAS BEEN FOUND. THUS 499
BASED ON $37.41/TON OF COKE, 1.45 TON OF COAL TO PRODUCE 1 TON 599
OF COKE, AND 38500 TON COAL/1.0E12 BTU (FOOTNOTE 1047), 29800 699
$/1.0E12 BTU WOULD BE THE INCREMENTAL TOTAL COST FOR AIR AND 799
WATER CONTROLS. 899

1123 199

PARTICULATE EMISSIONS IN COMPLIANCE WITH THE NEW SOURCE 299
PERFORMANCE STANDARDS FOR COAL THERMAL DRYERS ARE LIMITED TO 399
.03 GRAIN/DSCF (1121). BASED ON 24000 DSCF/TON DRY COAL INPUT 499
TO DRYER (1121) AND 197.2 T/HR INPUT TO DRYER/500 T/HR COAL 599
FEED TO PREP PLANT (FOOTNOTES 1813,1821,1822), THE PARTICULATE 699
EMISSION IS .833 TON/1.0E12 BTU AND CAN BE ATTAINED BY THE USE 799
OF A VENTURI-TYPE WET SCRUBBER AND MIST ELIMINATOR. THE SO2 899
AND NOX EMISSIONS ASSOCIATED WITH THE COMBUSTION OF COAL IN 999
THE THERMAL DRYER ARE GIVEN AS 4.5E-02 LB SO2 AND 5.35E-01 LB 1099
NOX PER 1.0E06 BTU COAL FIRED (1121). BASED ON 1 TON OF COAL 1199
COMBUSTED TO DRY 100 TONS IN A FLUIDIZED BED DRYER (1048), AND 1299
ON 26.2E06 BTU/TON OF COAL FED TO THE DRYER (FOOTNOTES 1813 1399
AND 1805), 9.67E-02 TON SO2 AND 1.15 TON NOX ARE EMITTED FOR 1499
EACH 1.0E12 BTU COAL INPUT TO THE METALLURGICAL PREP PLANT. 1599
EMISSIONS ASSOCIATED WITH THE BURNING COAL REFUSE PILE (SEE 1699
FOOTNOTE 1814) ARE COMPLETELY ELIMINATED BY RECLAMATION OF THE1799
REFUSE PILE. BAGHOUSES FOR CONTROL OF FUGITIVE DUST EMISSIONS 1899
ARE USED IN THE CONTROLLED MET PREP PLANT AT THE ROTARY 1999
BREAKER AND AT TRANSFER POINTS NEAR THE RAW COAL BINS, CLEANED2099
COAL BINS, AND LOAD-OUT BINS, IN ORDER TO COMPLY WITH THE 10P 2199
OPACITY LIMIT FOR VISIBLE EMISSIONS FROM NEW PREP PLANTS(1121) 2299

1124 199

SEEPAGE FROM THE REFUSE PILE IS ASSUMED TO BE COMPLETELY 299
ELIMINATED BY THE SOIL COVER ESTABLISHED IN RECLAIMING THE 399
REFUSE PILE. RUNOFF FROM THE REFUSE PILE, HOWEVER, CONTINUES 499
BECAUSE OF THE 3 YEAR TIME LAG ASSOCIATED WITH ESTABLISHMENT 599
OF AN HERBACEOUS COVER (SEE FOOTNOTE 1103). BASED ON 2.54 TON 699
SUSPENDED SOLIDS/ACRE-YR-IN RUNOFF AND ON 15 IN RUNOFF (SEE 799

FOOTNOTE 1072) AND 2.91E-01 ACRE-YR/1.0E12 BTU (FOOTNOTE 1128) 899
11.1 TON SUSPENDED SOLIDS/1.0E12 BTU ARE GENERATED IN RUNOFF 999
FROM THE RECLAIMED REFUSE PILE. SUSPENDED SOLIDS GENERATED IN 1099
THE PREP PLANT ARE ELIMINATED BY THE USE OF A SETTLING POND. 1199
1125 199
IT HAS NOT BEEN POSSIBLE TO QUANTIFY FUGITIVE DUST EMISSIONS FROM 299
COAL PREP PLANTS. THUS IT IS NOT POSSIBLE TO QUANTIFY THE 399
INCREMENTAL SOLID WASTE GENERATED BY THE USE OF BAGHOUSES TO 499
CONTROL THESE EMISSIONS. THEREFORE,THE SOLID WASTE GENERATED 599
IN THE CONTROLLED METALLURGICAL COAL PREP PLANT IS THE SAME AS 699
GIVEN IN FOOTNOTE 1813, NAMELY 8110 TON/1.0E12 BTU. 799
1126 199
THE COST FOR CONTROLS ON A METALLURGICAL COAL PREP PLANT ARE GIVEN 299
IN THIS SECTION. 399
COSTS FOR CONTROLLING AIR EMISSIONS 499
THE CAPITAL COST FOR A VENTURI SCRUBBER AND MIST ELIMINATOR 599
FOR A 250 T/HR THERMAL DRYER IN A 500 T/HR COAL PREP PLANT IS 699
$200000 (1080,64). SCALING THIS BY A .6 EXPONENT GIVES A 799
CAPITAL COST FOR A SCRUBBER ON A 200 T/HR DRYER OF $175000(SEE 899
FOOTNOTE 1814). THE SCRUBBER ON THE DRYER IN (1080,64) IS FOR 999
A PLANT PROCESSING 1.74E06 TON COAL/YR (500 T/HR AND 3480 HR/ 1099
YR OPERATION). THUS FOR A PLANT PROCESSING 41000 TON COAL/YR 1199
(EQUIVALENT TO 1.0E12 BTU/YR) THE ASSOCIATED CAPITAL COST FOR 1299
A VENTURI SCRUBBER-MIST ELIMINATOR SYSTEM IS 412 $/1.0E12 BTU 1399
(AT 10P FCR). THE OPERATING COSTS FOR A SCRUBBER ON A 250 T/ 1499
HR THERMAL DRYER AMOUNT TO 50350 $/YR (1080,81). SCALING THIS 1599
DIRECTLY FOR A 200 T/HR DRYER AND SIZING THE RESULTING COST 1699
FOR A 1.0E12 BTU/YR COAL PREP PLANT GIVES AN OPERATING COST OF1799
949 $/1.0E12 BTU. 1899
THE CAPITAL COST FOR 7 BAGHOUSES TO CONTROL FUGITIVE DUST FROM1999
A 500 T/HR PREP PLANT IS $260000 (1080,64). THIS PLANT 2099
PROCESSES 1.74E06 TON COAL/YR (BASED ON 3480 HR/YR OPERATION).2199
THUS FOR A PREP PLANT PROCESSING 41000 TON COAL/YR (1.0E12 BTU2299
/YR) THE ASSOCIATED CAPITAL COST IS 613 $/1.0E12 BTU (AT 10P 2399
FCR). THE OPERATING COST FOR THE 7 BAGHOUSES, EACH RATED AT 2499
10000 CFM, IN THE 500 T/HR PREP PLANT IS 12500 $/YR (1080,73).2599
THUS THE OPERATING COST FOR BAGHOUSES IN A 1.0E12 BTU/YR COAL 2699
PREP PLANT IS 294 $/1.0E12 BTU. 2799
COSTS FOR RECLAMATION OF SOLID WASTES 2899
THE CAPITAL COST ASSOCIATED WITH RECLAMATION OF THE COAL PREP 2999
PLANT REFUSE PILE IS TAKEN AS THE AVERAGE CAPITAL COST FOR THE3099
IDAMAY MINE NO.44 (UNDERGROUND) IN BARRACKVILLE,W.VA., MINE 3199
19 (STRIP) IN HALLOWELL,KANSAS, AND THE COLONIAL MINE (STRIP) 3299
IN MADISONVILLE,KENTUCKY (1115,3) AND IS $314,300. THIS 3399
EQUIPMENT WAS USED TO RECLAIM AN AVERAGE OF 9.67E06 TONS OF 3499
REFUSE (1115,5,10,19). BASED ON A TOTAL PLANT-LIFE REFUSE 3599
GENERATION OF 2.025E05 TON FOR A 1.0E12 BTU/YR MET PREP PLANT 3699
(8110 TON/YR FOR 25 YR (FOOTNOTE 1813)), THE CAPITAL COST IS 3799
660 $/YR (AT 10P FCR). THE 3-MINE AVERAGE OPERATING COST FOR 3899
REFUSE DISPOSAL IS .16 $/TON-MILE. ASSUMING AN AVERAGE HAULAGE3999
DISTANCE OF 1 MILE AND 8110 TON REFUSE/YR (FOOTNOTE 1813) 4099
GIVES A REFUSE DISPOSAL COST OF 1297 $/1.0E12 BTU. THE AVERAGE4199
REFUSE SPREADING AND COMPACTION COST (FOR THE IDAMAY AND 4299
COLONIAL MINES) IS GIVEN AS .08 $/TON OR 648 $/1.0E12 BTU. 4399
THE 3-MINE AVERAGE OPERATING COST FOR SOIL COVERING AND 4499
PLANTING IS 832 $/ACRE. BASED ON 2.025E05 TON REFUSE GENERATED4599
OVER THE 25 YR LIFETIME OF THE PREP PLANT AND AN ASSUMED 4699

REFUSE DENSITY AFTER COMPACTION OF .06 TON/CF, A TOTAL OF 4799
3.38E06 CF OF REFUSE MUST BE RECLAIMED. THIS REFUSE IS ASSUMED 4899
TO BE STACKED 30 FT HIGH AND SLOPED AT A 37 DEGREE ANGLE OF 4999
REPOSE. THE TOTAL LAND REQUIRED FOR RECLAMATION (ON THE SLOPES 5099
AND TOP) IS 3.42 ACRES. THE TOTAL SOIL COVERING AND PLANTING 5199
COST IS THUS $2840 BUT IS INCURRED OVER 25 YR OF PREP PLANT 5299
OPERATION. THE YEARLY COST IS $114. THE TOTAL OPERATING COST 5399
FOR RECLAMATION IS THE SUM OF COSTS FOR REFUSE DISPOSAL, 5499
REFUSE SPREADING AND COMPACTION, AND SOIL COVERING AND 5599
PLANTING OR 2059 $/1.0E12 BTU. 5699

COSTS FOR CONTROLLING WATER POLLUTANTS 5799

SUSPENDED SOLIDS CAN BE COMPLETELY ELIMINATED BY CLOSING THE 5899
WATER CIRCUIT THROUGH A SETTLING POND. FOR A 500 TON/HR PREP 5999
PLANT THE CAPITAL COST IS $136000 (1116). THE PLANT IN (1116) 6099
OPERATES 14 HR/D, 250D/YR AND PROCESSES 1.75E06 TON COAL/YR. 6199
THE CAPITAL COST FOR A 1.0E12 BTU/YR PREP PLANT IS THUS 319 6299
$/1.0E12 BTU (AT 10P FCR). (1116) GIVES THE OPERATING COSTS 6399
FOR THE SETTLING POND SYSTEM AS .0595 $/TON SUSPENDED SOLID. 6499
THE TOTAL SUSPENDED SOLIDS GENERATED IN THE PREP PLANT IS THE 6599
SUM OF 205 TON FROM THE UNCONTROLLED METALLURGICAL PREP PLANT 6699
(FOOTNOTE 1815) AND 47.8 TON PRODUCED BY THE VENTURI WET 6799
SCRUBBER (THE DIFFERENCE IN PARTICULATE EMISSIONS FOR THE 6899
UNCONTROLLED THERMAL DRYER (FOOTNOTE 1814) AND CONTROLLED 6999
DRYER (FOOTNOTE 1123)), OR 252.8 TON SUSPENDED SOLIDS. THUS 7099
THE OPERATING COST FOR A SETTLING POND IS 15.1 $/1.0E12 BTU. 7199
BOTH CAPITAL AND OPERATING COSTS HAVE BEEN ESCALATED FROM 7299
THEIR 1965 BASIS TO 1972 $. 7399

CONTROL COST SUMMARY 7499

CAPITAL COST-$/1.0E12 BTU		OPERATING COST-$/1.0E12 BTU		
412	THERMAL DRYER	949	THERMAL DRYER	7699
613	7 BAGHOUSES	294	7 BAGHOUSES	7799
660	REFUSE RECLAMATION	2059	REFUSE RECLAMATION	7899
386	WATER CLARIFICATION	18	WATER CLARIFICATION	7999
2071	TOTAL INCREMENTAL	3320	TOTAL INCREMENTAL	8099
CAPITAL COST FOR CONTROLS		OPERATING COST FOR CONTROLS		8199

1127 199

THE ENERGY REQUIREMENTS ASSOCIATED WITH CONTROLS ON A 1.0E12 BTU/ 299
YR METALLURGICAL COAL PREP PLANT ARE GIVEN HERE. A VENTURI 399
SCRUBBER ON A 250 TON/HR THERMAL DRYER REQUIRES 2.69E06 KWH/ 499
YR (1080,81). SCALING THIS DIRECTLY FOR A 200 TON/HR DRYER, 599
SIZING THE RESULTING ENERGY REQUIREMENT FOR A 1.0E12 BTU/YR 699
COAL PREP PLANT (SEE FOOTNOTE 1126), AND CONVERTING THE KWH 799
INTO BTU BY 10200 BTU/KWH GIVES AN ENERGY REQUIREMENT FOR 899
OPERATION OF THE VENTURI SCRUBBER OF 5.19E08 BTU/1.0E12 BTU. 999
THE TOTAL POWER REQUIREMENT FOR THE 7 BAGHOUSES IN A 500 TON/ 1099
HR PREP PLANT IS 175 HP (1080,73) OR 4.55E05 KWH/YR (BASED ON 1199
3480 HR/YR OPERATION). CONVERTING THIS BY 10200 BTU/KWH AND 1299
SIZING THE RESULT FOR A 1.0E12 BTU/YR PREP PLANT GIVES AN 1399
ENERGY REQUIREMENT OF 1.095E08 BTU/1.0E12 BTU. NO INFORMATION 1499
WAS AVAILABLE ON ENERGY REQUIREMENTS FOR REFUSE RECLAMATION. 1599
THE ENERGY REQUIRED FOR THE CLOSED CIRCUIT SETTLING POND IS 1699
BASED ON .0378 $/TON SUSPENDED SOLIDS (1116) OR .0457 $/TON 1799
(ESCALATED TO 1972 COSTS), 252.8 TON SUSPENDED SOLIDS (FOOTNOTE 1899
1126) AND $.01/KWH TO GIVE 1.18E03 KWH/1.0E12 BTU OR 1.18E07 1999
BTU/1.0E12 BTU (CONVERTING AT 10200 BTU/KWH). THE SUM TOTAL 2099
INCREMENTAL ENERGY DEMAND ASSOCIATED WITH CONTROLS ON A 1.0E 2199
12 BTU/YR METALLURGICAL COAL PREP PLANT IS THUS 6.40E08 BTU/ 2299
1.0E12 BTU. 2399

1128

BASED ON A SOLID WASTE PRODUCTION OF 9110 TON/1.0E12 BTU (FOOTNOTE 1813), A COMPACTED REFUSE DENSITY OF .06 TON/CF, AND A 30 FT HIGH REFUSE PILE, .103 ACRES OF LAND/1.0E12 BTU IS IMPACTED. BASED ON A 3 YEAR TIME LAG TO ESTABLISH AN HERBACEOUS COVER AND A 25 YR PLANT OPERATING LIFETIME, 2.82 TIMES THE YEARLY LAND IMPACT REPRESENTS THE TIME AVERAGED LAND IMPACT (FOOTNOTE 1103). THUS .291 ACRE-YR/1.0E12 BTU IS THE TIME AVERAGED LAND IMPACT. THE LAND REQUIREMENT FOR THE MET COAL PREP PLANT IS 1.95 ACRE-YR/1.0E12 BTU (FOOTNOTE 1073) SO THAT THE TOTAL LAND REQUIREMENT IS 2.24 ACRE-YR/1.0E12 BTU.

1129

EMISSIONS ASSOCIATED WITH THE BURNING COAL REFUSE PILE (FOOTNOTE 1074) ARE COMPLETELY ELIMINATED BY RECLAMATION OF THE REFUSE PILE. BAGHOUSES FOR CONTROL OF FUGITIVE DUST EMISSIONS ARE USED IN THE CONTROLLED UTILITY PREP PLANT IN ORDER TO COMPLY WITH THE 10P OPACITY LIMIT FOR VISIBLE EMISSIONS FROM NEW PREP PLANTS (1121).

1130

SEEPAGE FROM THE REFUSE PILE IS ASSUMED TO BE COMPLETELY ELIMINATED BY THE SOIL COVER ESTABLISHED IN RECLAIMING THE REFUSE PILE. RUNOFF FROM THE REFUSE PILE, HOWEVER, CONTINUES BECAUSE OF THE 3 YEAR TIME LAG ASSOCIATED WITH ESTABLISHMENT OF AN HERBACEOUS COVER (FOOTNOTE 1103). BASED ON 2.54 TON SUSPENDED SOLIDS/ACRE-YR-IN RUNOFF AND ON 15 IN RUNOFF (SEE FOOTNOTE 1072) AND .135 ACRE-YR/1.0E12 BTU (FOOTNOTE 1134), 5.14 TON SUSPENDED SOLIDS/1.0E12 BTU ARE GENERATED IN RUNOFF FROM THE RECLAIMED REFUSE PILE. SUSPENDED SOLIDS GENERATED IN THE PREP PLANT ARE ELIMINATED BY THE USE OF A SETTLING POND.

1131

IT HAS NOT BEEN POSSIBLE TO QUANTIFY FUGITIVE DUST EMISSIONS FROM COAL PREP PLANTS. THUS IT IS NOT POSSIBLE TO QUANTIFY THE INCREMENTAL SOLID WASTE GENERATED BY THE USE OF BAGHOUSES TO CONTROL THESE EMISSIONS. THEREFORE, THE SOLID WASTE GENERATED IN THE CONTROLLED UTILITY COAL PREP PLANT IS THE SAME AS GIVEN IN FOOTNOTE 1071, NAMELY 3750 TON/1.0E12 BTU.

1132

THE COST FOR CONTROLS ON A UTILITY COAL PREP PLANT ARE GIVEN HERE.

COSTS FOR CONTROLLING AIR EMISSIONS

THE CAPITAL COST FOR 7 BAGHOUSES TO CONTROL FUGITIVE DUST FROM A 500 T/HR PREP PLANT IS $260000 (1080,64). THIS PLANT PROCESSES 1.74E06 TON COAL/YR (BASED ON 3480 HR/YR OPERATION). THUS FOR A PREP PLANT PROCESSING 41000 TON COAL/YR (1.0E12 BTU /YR) THE ASSOCIATED CAPITAL COST IS 613 $/1.0E12 BTU (AT 10P FCR). THE OPERATING COST FOR THE 7 BAGHOUSES, EACH RATED AT 10000 CFM, IN THE 500 T/HR PREP PLANT IS 12500 $/YR (1080,73). THUS THE OPERATING COST FOR BAGHOUSES IN A 1.0E12 BTU/YR COAL PREP PLANT IS 294 $/1.0E12 BTU.

COSTS FOR RECLAMATION OF SOLID WASTES

BASED ON .03255 $/TON REFUSE RECLAIMED (SEE FOOTNOTE 1126) AND A TOTAL UTILITY PREP-PLANT-LIFE REFUSE GENERATION OF 9.38E04 TON (3754 TON/YR FOR 25 YR (FOOTNOTE 1071)), THE CAPITAL COST ASSOCIATED WITH RECLAMATION IS 305 $/YR (AT 10P FCR). THE OPERATING COSTS FOR REFUSE DISPOSAL, SPREADING, AND COMPACTION AMOUNT TO $.24/TON REFUSE (FOOTNOTE 1126) SO THAT FOR 3754 TON /YR A COST OF 900 $/1.0E12 BTU IS INCURRED. BASED ON 9.38E04 TON REFUSE GENERATED OVER THE 25 YR LIFETIME OF THE UTILITY

PREP PLANT AND ON CRITERIA SET FORTH IN FOOTNOTE 1126, THE 2299
TOTAL LAND REQUIRED FOR RECLAMATION (ON THE SLOPES AND TOP) 2399
IS 1.78 ACRES. BASED ON A SOIL COVERING AND PLANTING COST OF 2499
832 $/ACRE THIS AMOUNTS TO $1480 INCURRED OVER 25 YR OF PLANT 2599
OPERATION, OR 59.2 $/YR. THE TOTAL OPERATING COST FOR 2699
RECLAMATION IS THUS 959.2 $/1.0E12 BTU. 2799

COSTS FOR CONTROLLING WATER POLLUTANTS 2899

SUSPENDED SOLIDS CAN BE COMPLETELY ELIMINATED BY CLOSING THE 2999
WATER CIRCUIT THROUGH A SETTLING POND. FOR A 500 TON/HR PREP 3099
PLANT, PROCESSING 1.75E06 TON COAL/YR, THE CAPITAL COST IS 3199
$136000 (1116). THUS FOR A 1.0E12 BTU/YR PREP PLANT THE 3299
CAPITAL COST IS $3190(1965 $) OR 386 $/1.0E12 BTU (1972 $ AND 3399
10P FCR). (1116) GIVES THE OPERATING COSTS FOR THE SETTLING 3499
POND SYSTEM AS .0595 $/TON SUSPENDED SOLIDS. THE TOTAL 3599
SUSPENDED SOLIDS GENERATED IN THE UTILITY PREP PLANT IS 41 3699
TONS/1.0E12 BTU (FOOTNOTE 1072). THUS THE OPERATING COST FOR 3799
A SETTLING POND IS 2.95 $/1.0E12 BTU (1972 $). 3899

CONTROL COST SUMMARY 3999

CAPITAL COST-$/1.0E12 BTU		OPERATING COST-$/1.0E12 BTU		
613	7 BAGHOUSES	294	7 BAGHOUSES	4199
305	REFUSE RECLAMATION	959	REFUSE RECLAMATION	4299
386	WATER CLARIFICATION	3	WATER CLARIFICATION	4399
1304	TOTAL INCREMENTAL	1256	TOTAL INCREMENTAL	4499
CAPITAL COST FOR CONTROLS		OPERATING COST FOR CONTROLS		4599

1133 199

THE TOTAL POWER REQUIREMENT FOR THE 7 BAGHOUSES IN A 500 TON/HR 299
PREP PLANT IS 175 HP (1080,73) OR 4.55E05 KWH/YR (BASED ON 399
3480 HR/YR OPERATION). CONVERTING THIS BY 10200 BTU/KWH AND 499
SIZING THE RESULT FOR A 1.0E12 BTU/YR PREP PLANT GIVES AN 599
ENERGY REQUIREMENT OF 1.095E08 BTU/1.0E12 BTU. NO INFORMATION 699
WAS AVAILABLE ON ENERGY REQUIREMENTS FOR REFUSE RECLAMATION. 799
THE ENERGY REQUIRED FOR THE CLOSED CIRCUIT SETTLING POND IS 899
BASED ON .0457 $/TON SUSPENDED SOLIDS (FOOTNOTE 1126), 41 TONS 999
OF SOLIDS (FOOTNOTE 1072), AND $.01/KWH TO GIVE 1.87E02 KWH/ 1099
1.0E12 BTU OR 1.91E06 BTU/1.0E12 BTU (CONVERTING AT 10200 BTU 1199
/KWH). THE SUM TOTAL INCREMENTAL ENERGY DEMAND ASSOCIATED WITH 1299
CONTROLS ON A 1.0E12 BTU/YR UTILITY COAL PREP PLANT IS THUS 1399
1.114E08 BTU/1.0E12 BTU. 1499

1134 199

BASED ON A SOLID WASTE PRODUCTION OF 3750 TON/1.0E12 BTU (FOOTNOTE 299
1071), A COMPACTED REFUSE DENSITY OF .06 TON/CF, AND A 30 FT 399
HIGH REFUSE PILE, .048 ACRES OF LAND/1.0E12 BTU IS IMPACTED. 499
BASED ON A 3 YEAR TIME LAG TO ESTABLISH A HERBACEOUS COVER 599
AND A 25 YR PLANT OPERATING LIFETIME, 2.82 TIMES THE YEARLY 699
LAND IMPACT REPRESENTS THE TIME AVERAGED LAND IMPACT (FOOTNOTE 799
1103). THUS .135 ACRE-YR/1.0E12 BTU IS THE TIME AVERAGED LAND 899
IMPACT. THE LAND REQUIREMENT FOR THE UTILITY COAL PREP PLANT 999
IS 1.95 ACRE-YR/1.0E12 BTU (FOOTNOTE 1073) SO THAT THE TOTAL 1099
LAND REQUIREMENT IS 2.09 ACRE-YR/1.0E12 BTU. 1199

1135

SEDIMENT RUNOFF FROM COAL HAULAGE ROADS CAN BE CONTROLLED BY DITCHING ALONGSIDE THE ROADS AND DIVERTING THE RUNOFF TO SMALL SETTLING PONDS. THE COST FOR DITCHING IS SMALL AND IS NORMALLY A PART OF THE ROAD CONSTRUCTION AND MAINTENANCE COST. THE CAPITAL COST FOR THE SETTLING POND IS TAKEN AS $20000 (1100) AND 5 PONDS ARE ASSUMED FOR A ROAD SERVICING A 2E06 TON /YR MINING OPERATION. THUS 205. $/1.0E12 BTU IS THE FIXED COST. INFORMATION ON OPERATING COSTS WAS NOT AVAILABLE.

1136

THE ENERGY CONSUMED BY THE SODA ASH TREATMENT FACILITY IS 8.16E09 BTU/YR (FOOTNOTE 1105, AT $0.015/KWH) AND IS ASSOCIATED WITH A 2E06 TON/YR MINE. FOR 1.0E12 BTU IN THIS ENERGY REQUIREMENT IS 1.34E08 BTU. THIS ENERGY CONSUMPTION IS PROBABLY MINOR IN COMPARISON TO THAT FOR THE MINING METHOD ITSELF. HOWEVER, ENERGY CONSUMPTION DATA FOR A MODIFIED BLOCK CUT TECHNIQUE WAS NOT AVAILABLE AND WAS THUS ASSUMED SIMILAR TO THAT FOR CONVENTIONAL CONTOUR STRIPPING, I.E. 1.07E10 BTU/1.0E12 BTU IN.

1137

IT IS ASSUMED THAT A SETTLING POND IS REQUIRED FOR EACH MILE OF ROAD AND THAT EACH POND USES AN ACRE. THUS, 5 AC ARE UTILIZED FOR THE SETTLING PONDS (THE HAUL ROAD IS 5.3 MI IN LENGTH, FOOTNOTE 1004). THE LAND IMPACT IS 0.103 AC-YR/1.0E12 BTU. THIS IS IN ADDITION TO THE LAND IMPACTED BY THE ROAD - 0.712 AC-YR/1.0E12 BTU (FOOTNOTE 1004).

(UNCONTROLLED) FUEL	REGION
COAL	NORTHWEST

ROW	MNE-MON.	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/10^{12}BTU)	13 PARTIC-ULATES	14 NO_x
			WATER POLLUTANTS (TONS/ 10^{12} BTU, EX COL 12)													
1	EXTRC	EXTRACTION														
2	SURFC	SURFACE-AREA														
3	STRP<	<15° SLOPE	0000	0000	0000	0000	6.94-01 3 1209	6.94-01 3	2.32+01 3 1209	0000	2.41+01 3	0000	0.00+00 1 0007	0000	2.27+00 4 1207	1.03+00 5
4	TRNSP	TRANSPORTATION														
5	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	3.11+01 3 1210	0000	3.11+01 3	0000	0000	0000	9.10-01 3 1211	7.00-01 3
6	PROCS	PROCESSING														
7	BREAK	PRIMARY BREAKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1009	
8	RCLEN	ROUGH CLEANING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1009	
9	RWSIZ	RAW COAL SIZING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1009	
10	BRKSZ	BREAKIN AND SIZING	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0.00+00 1 1076	0000	0.00+00 1 1076	0000	0.00+00 2 1009	
11	DISTR	DISTRIBUTION														
12	UNITT	UNIT TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.57+01 4 1217	2.87+00 5
13	MIXT	MIXED TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.03+01 4 1218	2.12+00 5
14	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.29-01 4 1219	1.89+00 5
15	STORA	COAL STORAGE														
16	ABOV	ABOVE GROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	
17	UGRND	UNDERGROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	
18	SILOS	SILOS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1200 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF NORTHWESTERN COAL AND REGIONAL DESCRIPTION.

	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
		AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	ROW
																	1
																	2
0000	0000	2.27+00 4 1207	1.93+00 5 1207	7.53-02 5 1207	1.13+01 5 1207	6.38-01 5 1207	1.67-02 5 1207	4.12-00 5	7.30+02 3 1208	1.07+01 5 1201	2.50-02 1 1201	5.69-02 1 1201	1.41+00 1 1201	1001	8.80-01 3 1208	1.92+00 5 1227	3
																	4
0000	0000	9.10-02 3 1211	2.90-01 3 1211	1.80-01 3 1211	1.39-02 3 1211	1.73-01 3 1211	2.10-02 3 1211	6.92-01 3	0000	2.74-01 1 1204	0.00+00 1 1203	7.70-02 1 1203	6.74-01 1 1203	1002	1.00+00 1 1213	1.84+00 3 1216	5
																	6
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1002	1.00+00 1 1207	0000	7
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	3.42+10 4 1216	0000	0000	0000	0000	1002	1.00+00 1 1207	0000	8
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1002	1.00+00 1 1207	0000	9
1070	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	3.42+00 4 1216	7.57-01 1 1 [illegible]	0.00+00 1 1203	5.55-03 2 1203	1.48-01 2 1203	1002	1.00+00 1 1213	2.19+00 4 1216	10
																	11
0000	0000	2.37+01 4 1217	2.67+00 3 1217	1.32+00 3 1217	1.18+00 3 1217	5.50+00 3 1217	3.32-01 3 1217	1.36-01 4	0000	7.51-01 3 1221	1.30-02 2 1222	5.40-01 1 1222	5.30-01 2 1222	1002	1.00+00 2 1220	6.80+00 3 1226	12
0000	0000	4.63-01 4 1218	2.12+00 3 1218	1.63+00 3 1218	1.41+00 3 1218	1.97+00 3 1218	5.10-01 3 1218	5.30+01 3	0000	7.51+01 3 1221	1.30-02 2 1222	5.40-01 2 1222	5.10+01 2 1222	1002	1.00-00 3 1220	7.53+00 3 1222	13
0000	0000	2.20+01 4 1219	1.69+00 3 1219	1.24-01 3 1219	1.60-01 3 1219	1.80+00 3 1219	7.75-02 3 1219	2.50+01 3	0000	0.00+00 1 0007	3.20-02 3 1223	6.62-01 3 1223	4.54+01 3 1223	1002	1.00-00 3 1220	1.07+00 3 1226	14
																	15
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.06-00 2 1236	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1007	8.80-01 3 1007	2.13+06 3 1226	16
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.06-00 2 1236	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	8.80-01 3 1007	2.13+06 3 1226	17
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.42+01 2 1237	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	9.83-01 3 1007	2.13+06 3 1226	18
																	19
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TABLE 3. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED NORTHWEST REGION OF COAL SUPPLY

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FOOTNOTES FOR TABLE 3

1200

THE NORTHWEST REGION FOR THIS STUDY IS COMPRISED SOLELY OF THE POWDER RIVER BASIN. THE AVERAGE CALORIC CONTENT OF THE COAL DELIVERED TO ELECTRIC UTILITIES IN MONTANA AND WYOMING DURING THE 3RD AND 4TH QUARTERS OF 1972 WAS ABOUT 8780 BTU/LB AND THE SULFUR CONTENT WAS APPROXIMATELY 0.85PC(1212,AND 1213). THE AVERAGE ASH CONTENT OF COAL FROM THE BIG SKY AND COLSTRIP MINES IN MONTANA AND THE BIG HORN MINE IN WYOMING IS 6.77P AS RECEIVED (1026 AND 1202). THE DENSITY OF THE COAL FROM THIS REGION IS 81 LB/CF (1201).
FOR THE COAL IN THIS REGION 1.0E12 BTU IS THE EQUIVALENT OF 57000 T. ALL THE COMPUTATIONS ARE BASED ON 1.0E12 BTU.
NONE OF THE SURFACE MINED COAL OF THIS REGION IS SUBJECTED TO ANY PREPARATION EXCEPT CRUSHING AND SIZING (1004,47). ALTHOUGH WASHABILITY STUDIES INDICATE THAT THESE COALS CAN BE WASHED (1216 AND 1217), MORE ELABORATE PREPARATION IS NOT FORESEEN (1008 AND 1021).

1201

THE OCCUPATIONAL HEALTH IMPACTS WITH RESPECT TO DEATH (FATALITIES), INJURIES (NON-FATALITIES) AND WORK DAYS LOST ARE BASED ON THE STATISTICS PRESENTED IN (1200) THROUGH (1210).
THE WORK-DAYS LOST PER INJURY QUANTITIES DURING STRIP MINING RESULT FROM AVERAGE SEVERITY STATISTICS TABULATED IN THE PREVIOUSLY CITED REFERENCES. AVERAGE SEVERITY IS DEFINED BY THE BUREAU OF MINES AS BEING THE NUMBER OF DAYS CHARGED (OR LOST) DIVIDED BY THE NUMBER OF INJURIES. AVERAGE SEVERITY QUANTITIES WERE USED BASED ON THE NUMBER OF TEMPORARY TOTAL DISABILITIES,THE OVERWHELMINGLY,LARGEST CATEGORY OF NON-FATAL INJURIES. TEMPORARY TOTAL DISABILITY IS DEFINED AS ANY NON-FATAL INJURY THAT DOES NOT RESULT IN PERMANENT IMPAIRMENT,BUT THAT RENDERS THE INJURED PERSON UNABLE TO PERFORM A REGULARLY ESTABLISHED JOB. THEREFORE,AS A RESULT OF STRIP MINING, AN AVERAGE OF 24.8 WORK-DAYS LOST PER INJURY (TEMPORARY TOTAL DISABILITY) IS DERIVED FOR MONTANA AND WYOMING FOR THE YEARS 1964-1966,1968 AND 1969.

1202

THE 'HAULAGE' STATISTICS PUBLISHED IN (1206) THRU (1210) WERE EMPLOYED HERE. HAULAGE ENCOMPASSES A BROAD CATEGORY WHICH INCLUDES THE FOLLOWING TRANSPORTATION MODES FOR THE COAL-(1)FROM AN UNDERGROUND MINE TO THE SURFACE BY RAIL AND 2)FROM THE SURFACE TO THE COAL PREPARATION PLANTS BY TRUCK. AFTER STRIP MINING IN THE STATES OF MONTANA AND WYOMING, NO FATALITIES FOR COAL HAULAGE WERE REPORTED OVER THE YEARS 1964-1966,1968 AND 1969. AN AVERAGE OF 0.473 NON-FATALITIES /1.0E6 TONS PRODUCTION WAS COMPUTED FOR COAL HAULAGE, OCCURRING PRIMARILY IN WYOMING.
AN APPROXIMATE AVERAGE OF 25 WORK-DAYS LOST PER INJURY IS ASSUMED FOR TRANSPORT FOLLOWING STRIP MINING. THIS QUANTITY RESULTS FROM AVERAGING THE WORK-DAYS LOST/INJURY FOR MONTANA AND WYOMING. THE BASIC STATISTICS ON AVERAGE SEVERITIES WERE COMPRISED OF CONTRIBUTIONS DUE TO STRIP MINING AND HAULAGE. THE RELATIVE CONTRIBUTION OF EACH CANNOT BE ISOLATED.

1203

THE STATISTICS UNDER 'MECHANICAL CLEANING PLANTS' OR 'COAL PREPARATION PLANTS' WERE EMPLOYED AS TABULATED IN REFERENCES 1208-1210.IN THE YEARS 1964-1966,1968 AND 1969, NO FATALITIES WERE REPORTED UNDER THESE CATEGORIES FOR THE STATES OF MONTANA

AND WYOMING. AN AVERAGE OF 0.0505 NON-FATALITIES /1.0E6 TONS 699
PRODUCTION OCCURRED AT MECHANICAL CLEANING PLANTS, LOCATED 799
PRIMARILY IN WYOMING. 899
AVERAGE SEVERITY STATISTICS (DEFINED IN FOOTNOTE 1201) HAVE 999
ONLY BEEN PRESENTED IN THE MORE RECENT REPORTS ENTITLED, 1099
'INJURY EXPERIENCE IN COAL MINING'. 1199
THEREFORE MAN-DAYS LOST PER INJURY COULD ONLY BE OBTAINED 1299
FROM AVERAGING THE AVAILABLE STATISTICS FOR THE YEARS 1966, 1399
1968 AND 1969. UNDER COAL PREPARATION, AN AVERAGE OF 51.5 1499
WORK-DAYS LOST PER INJURY (TEMPORARY TOTAL DISABILITY) WAS 1599
COMPUTED FOR THE STATES OF MONTANA AND WYOMING. 1699

1204 199

IN 1969 THE AVERAGE HAULAGE DISTANCE FROM STRIP MINE TO TIPPLE WAS 299
1.5 MILES (0001,344). DATA FROM STUDIES CONDUCTED IN EASTERN 399
KENTUCKY (1024)&(1031)THRU (1034) INDICATE AN AVERAGE 499
HAULAGE ROAD RIGHT-OF-WAY OF 6.4 AC / MI. ASSUMING AN ANNUAL 599
PRODUCTION OF 2MMT, 2.85PC OF ROAD USAGE IS ATTRIBUTABLE TO THE 699
TRANSPORT OF 1.0E12 BTU EQUIVALENT T. HENCE, THE LAND IMPACT 799
IS 0.274 AC-YR / 1.0E12 BTU. 899

1205 199

THE AVERAGE DENSITY OF COAL IN MONTANA IS APPROXIMATELY 81 LB/CF 299
(FOOTNOTE 1201). THE AVERAGE THICKNESS OF COAL SEAMS MINED IN 399
THE POWDER RIVER BASIN IS ABOUT 39 FEET, WHICH WAS COMPUTED 499
FROM DATA IN REFERENCES(1203,32) & (1204,6). THUS, THE 599
INCREMENTAL LAND DAMAGED IS 0.828 AC / 1.0E12 BTU, AND THE 699
TIME AVERAGED (OVER 25 YEARS) LAND IMPACT IS 10.4 AC-YR / 799
1.0E12 BTU IN. 899
SINCE IN STRIP MINING SOLID WASTE IS PRODUCED ONLY FROM THE 999
SPOILS OF THE FIRST CUT AND ARE PERMANENTLY SITUATED,THE LAND 1099
THE SOLID WASTE OCCUPIES IS CLASSIFIED AS FIXED LAND IMPACT. 1199
FOR SOLID WASTE STORAGE IN A PILE 30 FEET HIGH, THE 1299
UTILIZED IS 0.279 AC-YR/1.0E12 BTU IN (SOLID WASTE PRODUC- 1399
TION, FOOTNOTE 1206). 1499

1206 199

THE DENSITY OF THE MINE REFUSE PILES WAS COMPUTED TO BE 0.05 TONS 299
/ CF FROM INFORMATION IN REFERENCE (1205). THE AVERAGE 399
OVERBURDEN DEPTH IS 60 FEET (WHICH WAS THE AVERAGE DEPTH 499
MINED IN WYOMING IN 1969 (1204) AND IN MONTANA IN 1965 (1017)). 599
IN AREA MINING,THE SOLID WASTE IS PRODUCED ONLY DURING THE BOX 699
CUT. ASSUMING THE BOX CUT COVERS AN AREA OF 5 AC (1007) AND 50 799
MMT OF COAL IS SUBSEQUENTLY EXTRACTED, SOLID WASTE IS PRODUCED 899
AT A RATE OF 730 T / 1.0E12 BTU IN. 999

1207 199

THE EMISSIONS FROM EXCAVATING EQUIPMENT FUEL USE ARE NEGL. ALL BUT 299
ONE PIECE OF EQUIPMT IN MONT. IS ELECTRICALLY POWERED WHILE 399
FOR WYOMING THE FIGURE IS 66PC(1004,38). 499
NEVERTHELESS OTHER EQUIPMENT IS DIESEL POWERED. THE DIESEL 599
FUEL CONSUMED FOR EACH 1.0E12 BTU IN IS ABOUT 5580 GAL. 699
(FOOTNOTE 1227). THE EMISSION FACTORS ARE OBTAINED FROM 799
REF. (0002,3-7). 899
BEING A SEMI-ARID AREA,WIND EROSION IS LIKELY TO OCCUR. THE 999
EXTENT IS DEPENDENT ON SOIL CONDITIONS, VEGETAL COVER AND 1099
PRECIPITATION. NO DUST PASSAGE HAS BEEN REPORTED AT GLASGOW, 1199
MONTANA AND RAPID CITY, S.D. (1211,9). BUT, DUE TO THE SURFACE 1299
DAMAGE CAUSED BY STRIP MINING,EROSION IS ASSUMED TO OCCUR AT A 1399
RATE OF 428 LB/AC-YR, WHICH IS THE RATE FOR THE MORE ERROSIVE 1499
SOUTHERN GREAT PLAINS (1211,18). HENCE, 2.23 T OF PARTICULATES 1599
ARE EMITTED FOR EVERY 1.0E12 BTU IN (SEE FOOTNOTE 1205). 1699

1208 199

THE EFFICIENCY OF EXTRACTION IS ABOUT 98PC(1021). 299

1209 199

SINCE NO EMPIRICAL RESULTS WERE AVAILABLE FOR THE SPECIFIC AREA, THE SEDIMENT YIELD FROM THE WASTE PILE IS COMPUTED FROM THE FOLLOWING EQUATION (1214).

E = F C (S EXP1.35) (L EXP0.75) (P EXP1.75)

WHERE, E = PROBABLE SOIL LOSS (T/AC-YR)
L = 120 FT = LENGTH OF SLOPE
F = 0.4 = SOIL FACTOR (RELATIVE ERODABILITY)
S = 8.4 = SLOPE IN PC/10
P = 1.5 = RAINFALL 2 YR FREQUENCY, 30 MINUTE MAXIMUM INTENSITY (INCHES)
C = 1.0 = CROP FACTOR

THE VALUES FOR F,P,AND C WERE OBTAINED FROM THE REFERENCE PAPER,WHILE S AND L WERE ESTIMATED .THE SEDIMENT YIELD IS 77.1 TONS/AC-YR.

IT IS ASSUMED THAT THE SOLID WASTE PILE ALONE WILL CONTRIBUTE SEDIMENT TO THE NATURAL DRAINAGE, SINCE THE SPOIL BANKS ARE LOCATED IN THE PIT AND THE RUNOFF IS CONTAINED THEREIN (THE RUNOFF FROM AND SEEPAGE IN THE SPOIL BANKS COULD CONTAMINATE THE GROUND WATER SUPPLY). THE REFUSE PILE REMAINS THE SAME THROUGHOUT THE LIFE OF THE MINE (ONE BOX CUT), AND OCCUPIES AN AREA OF 0.279 ACRE-YR/1.0E12 BTU IN. HENCE, THE SEDIMENT YIELD FROM THE REFUSE PILE IS 21.5 TONS/1.0E12 BTU IN.

INFORMATION ON THE DECKER MINE INDICATE THAT 150 GALLONS PER MINUTE ARE BEING PUMPED INTERMITTENTLY FROM THE MINE (1021 AND 1022) SINCE THE DECKER MINE IS NEW AND THE ONLY ONE IN THE AREA, THE GROUNDWATER SEEPAGE INTO THE MINE IS EXCEPTIONALLY HIGH.THUS FOR THIS ANALYSIS A FIGURE OF 50 GPM PUMPING 50 PERCENT OF THE TIME IS ASSUMED. AT AN AVERAGE PRODUCTION OF 8300 TONS COAL PER DAY, ABOUT 4.3 GALLONS OF WATER ARE YIELDED FOR EACH TON OF COAL EXTRACTED.

THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	REF.	PPM	T/1.0E12 BTU IN
SUSPENDED SOLIDS (COAL FINES)	(1022)	1600	1.7
SEDIMENT			21.5
SUBTOTAL			23.2
K AND NA	(1215)	210	0.216
FE	(1215)	25	0.026
SULFATE	(1215)	413	0.426
CA	(1215)	92	0.095
MG	(1215)	127	0.131
SUBTOTAL			0.894

1210

THE SEDIMENT YIELD FROM THE HAULAGE ROADS IS ASSUMED TO OCCUR AT THE SAME RATE AS FROM THE SPOIL PILES (77.1 T/AC-YR, FOOTNOTE 1209). HENCE, 21.1 T/1.0E12 BTU OF SILT IS CONTRIBUTED TO THE RUNOFF (FOOTNOTE 1204, LAND USE BY HAUL ROAD).

1211

THE AVERAGE HAULAGE DISTANCE FROM STRIP MINE TO TIPPLE IS 1.5 MI AND THE AVERAGE TRUCK CAPACITY IS 62 T (0001,344). ASSUMING A GROSS TO TARE WEIGHT RATIO OF 2.5 TO 1, A ROUND TRIP TRANSPORTS 217 TMI. FUEL CONSUMPTION IS AT A RATE OF 7 GAL/1000 TMI (0002,3-7). HENCE, SINCE 920 TRIPS ARE REQUIRED TO HAUL 1.0E12 BTU EQUIVALENT TONS, 1400 GAL OF DIESEL FUEL ARE CONSUMED. THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7).

THE FUGITIVE DUST FROM THE HAULAGE ROADS IS ASSUMED TO BE CONTROLLED. GENERAL PRACTICE IS TO WATER DOWN THE ROADS.

1212

DIESEL FUEL IS CONSUMED AT A RATE OF 1400 GAL FOR EVERY 1.0E12 BTU EQUIVALENT TONS TRANSPORTED (FOOTNOTE 1211). THUS, FOR ENERGY CONTENT OF 5.83E6 BTU/BBL OF DIESEL FUEL, 1.94E8 BTU OF ENERGY IS CONSUMED.

1213

NO COAL IS ASSUMED LOST BETWEEN MINE AND TIPPLE.

1214

IT IS ASSUMED THAT .006PC OF THE FEED TO THE PREPARATION PLANT IS REMOVED AS TRAMP IRON. HENCE, 3.42 T OF TRAMP IRON IS COLLECTED FOR EVERY 1.0E12 BTU EQUIVALENT T PROCESSED. THE PERCENTAGE OF TRAMP IRON IS ESTIMATED FROM INFORMATION IN REF. (1059,6-31), ASSUMING THAT THE LARGE PLANT PROCESSES 1000 T/HR.

1215

THE AMOUNT OF FEED REMOVED AS TRAMP IRON IS MINISCULE (.006 PC). THE EFFICIENCY IS THEREFORE APPROXIMATELY 100PC.

1216

APPROXIMATELY 35AC OF LAND ARE UTILIZED FOR THE PREPARATION PLANT AND A 10000 T UNIT TRAIN LOADING FACILITY (1021). THUS, THE LAND IMPACT IS ABOUT 0.997 AC-YR/1.0E12 BTU.
IT IS ASSUMED THAT THE MODES OF TRANSPORT OTHER THAN UNIT TRAINS HAVE SIMILAR LAND REQUIREMENTS.

1217

IN GENERAL, A UNIT TRAIN HAULS 10,000 T OF COAL PER TRIP (1005,33) AND UTILIZES THE EQUIVALENT OF 4, 2400 HP DIESEL LOCOMOTIVES (FROM DATA ON MATTHEWS MINE IN (1006)).

ENERGY CONSUMPTION BY FREIGHT TRAINS IS 690 BTU/TM (FOOTNOTE 7013), OR 0.005 GAL DIESEL FUEL/TM (5.83E6 BTU/BBL,0005,38). AN ALL STEEL HOPPER CAR WITH A CAPACITY OF 70 T HAS A GROSS TO TARE WEIGHT RATIO OF ABOUT 4/1 (0023,1136). IT IS ASSUMED THAT THIS FIGURE HOLDS FOR 100 T CARS AND THAT THE FUEL CONSUMPTION PER TRAIN IS AS CITED ABOVE. FROM DATA IN (0021,31) THE ENERGY CONSUMPTION ASSUMES AN AVERAGE USAGE OF 3 LOCOMOTIVES PER THE AVERAGE HAULAGE DISTANCE, ASSUMED TO BE 150 MI WHICH IS THE APPROXIMATE DISTANCE BETWEEN DECKER AND BILLINGS, MONTANA (LOCATED IN BILLINGS IS THE LARGEST COAL BURNING POWER PLANT IN MONTANA (1218,39)). HENCE, FUEL CONSUMPTION IS 12500 GAL PER ROUND TRIP OR 7.13E4 GAL/1.0E12 BTU. THE EMISSION FACTORS ARE COMPUTED FROM (0002,3-7).
WINDAGE LOSSES, ASSUMED TO BE AIRBORNE AS PARTICULATES, ARE ABOUT .04P OF THE TONNAGE HAULED (0002, 7-4). SINCE THE LOSSES OCCUR MAINLY DURING HANDLING AT EITHER END POINT, THEY ARE ESSENTIALLY INDEPENDENT OF HAULAGE DISTANCE. THUS, 22.8 T OF COAL FINES ARE RELEASED AS PARTICULATES FOR EACH 1.0E12 BTU EQUIVALENT T SHIPPED.

1218

THE AVERAGE HAULAGE DISTANCE IS 150 MI (1005,96) AND FUEL CONSUMPTION IS AT A RATE OF .005 GAL/TM (FOOTNOTE 1005). ASSUMING 1000 T IS CARRIED PER TRIP AND ACCOUNTS FOR 20P OF THE TOTAL TONNAGE OF ANY ONE SHIPMENT, A GROSS TO TARE WEIGHT RATIO OF 4/1, AND ONLY ONE WAY DIESEL FUEL CONSUMPTION ATTRIBUTED TO COAL, 56400 GAL OF DIESEL FUEL CONSUMED ARE ATTRIBUTED TO THE TRANSPORT OF 1.0E12 BTU. THE EMISSIONS ARE COMPUTED FROM INFORMATION ON DIESEL LOCOMOTIVES IN (0002,3-7). THE WINDAGE LOSSES ARE ASSUMED TO BE APPROXIMATELY .08P OF THE TOTAL SHIPMENT. HENCE, ABOUT 45.6 T IS RELEASED TO THE ATMOSPHERE AS PARTICULATES/1.0E12 BTU.

1219

DUE TO THE LARGE COAL DEPOSITS IN THE AREA AND THE PROXIMITY OF OF THE POPULATION CENTERS IN THE REGION, A SIZABLE PERCENTAGE OF THE POWER PLANTS ARE LOCATED AT MINE-MOUTH.
IT IS ASSUMED THAT TRUCK HAULAGE DISTANCE AVERAGES 10 MI. THIS

IS THE APPROXIMATE DISTANCE BETWEEN GLENROCK, WYOMING, WHERE 699
THE LARGEST COAL FIRING POWER PLANT IN THE REGION IS LOCATED, 799
(1218,41), AND THE COAL DEPOSITS (1204,21). 899
ASSUMING AN AVERAGE TRUCK CAPACITY OF 20 T, A GROSS TO TARE 999
WEIGHT RATIO OF 2.5 TO 1 AND A FUEL CONSUMPTION RATE OF 7 1099
GAL/1000 TMI (FOOTNOTE 1211), 9160 GAL OF DIESEL FUEL ARE 1199
CONSUMED. THE EMISSIONS FROM A DIESEL ENGINE ARE GIVEN IN REF. 1299
(0002,3-7). 1399
IT IS ASSUMED THAT .04P OF THE TOTAL SHIPMENT IS LOST DUE TO 1499
WINDAGE. THE COAL FINES RELEASED AS PARTICULATES THEREFORE 1599
AMOUNT TO 22.8 T/1.0E12 BTU EQUIVALENT T SHIPPED. 1699

1220 199

WINDAGE LOSSES ACCOUNT FOR .04P OF THE TONNAGE SHIPPED BY UNIT 299
TRAIN AND TRUCK (FOOTNOTE 1217 AND 1219), WHILE FOR MIXED 399
TRAINS THE LOSSES ARE .08PC(FOOTNOTE 1218). 499

1221 199

THE AVERAGE MILES OF RAILROAD OPERATED WEST OF THE MISSISSIPPI IN 299
1971 WERE 119,000 MI (0033,59) AND OF THE TOTAL TONNAGE HAULED 399
IN THE SAME YEAR COAL ACCOUNTED FOR 9PC(0039,27). 499
ASSUMING A RIGHT-OF-WAY OF 6 AC/MI, THE LAND UTILIZATION 599
ASSOCIATED WITH THE TRANSPORT OF COAL IS 64200 AC. 699
RAIL SHIPMENT OF COAL FROM MONTANA AND WYOMING IN 1971 AMOUNT- 799
ED TO 11.7E6 T (1004,52,53) OR ABOUT 24 PC OF THE TOTAL COAL 899
MOVEMENT BY RAIL WEST OF THE MISSSIPPI RIVER. THUS, THE LAND 999
IMPACT IS 75.1 AC-YR/1.0E12 BTU. 1099

1222 199

COAL SHIPMENT IN THE REGION WEST OF THE MISSISSIPPI ACCOUNTS FOR 299
9P OF THE TOTAL FREIGHT MOVEMENT IN THIS REGION (0039,27) AND 399
24 PC OF THE COAL MOVEMENT ORIGINATED IN MONTANA AND WYOMING. 499
(1004,52/53). IN THIS REGION,ACCIDENTS CLAIMED 714 LIVES AND 599
INJURED 5700 PERSONS (0006,17,54), AND AN AVERAGE OF 93 MAN- 699
DAYS WERE LOST PER INJURY (0006,4). HENCE, .0750 FATALITIES, 799
0.599 NON-FATAL INJURIES AND 55.6 MAN-DAYS LOST ARE ATTRIBUT- 899
ABLE TO THE SHIPMENT OF 1.0E12 BTU EQUIVALENT T FROM MONTANA 999
AND WYOMING (SEE FOOTNOTE 1221 FOR COAL TONNAGE). 1099

1223 199

THE ACCIDENT STATISTICS FOR COAL IN 1970 ARE INCLUDED IN THE 'NOT 299
ELSEWHERE CLASSIFIED' CATEGORY IN REF.(0036,14). IN MATCHING 399
DATA WITH REF. (0037,2/9) IT HAS BEEN DEDUCED THAT IN 1970 499
METALLIC ORES, COAL, NON-METALLIC MINERALS AND WASTE AND SCRAP 599
METALS ARE INCLUDED IN THIS CATEGORY. OF THE TOTAL TONNAGE OF 699
THESE COMMODITIES,COAL ACCOUNTS FOR 3PC-- A TRANSPORT OF 799
341,000 TONS. OF THE TOTAL TONNAGE OF COAL SHIPPED, 1.0E12 BTU 899
EQUIVALENT T AMOUNTS TO 12PC. HENCE, 0.0324 FATALITIES/1.0E12 999
BTU AND 0.692 NON-FATAL INJURIES/1.0E12.BTU IS ATTRIBUTED 1099
TO THE SHIPMENT OF COAL. FOR THE SAME YEAR THE NUMBER OF 1199
DAYS LOST PER INJURY FOR 'TRUCKING, LOCAL AND LONG DISTANCE' 1299
WAS 65.6 (0038,375). THUS, 45.4 DAYS ARE LOST/1.0E12 BTU. 1399
NO REGIONAL DATA HAVE BEEN LOCATED. 1499

1224 199

THE UNIT TRAIN CONSUMES 7.13E4 GAL OF DIESEL FUEL/1.0E12 BTU 299
EQUIVALENT T OF COAL TRANSPORTED (FOOTNOTE 1217). FOR A HEAT 399
CONTENT OF 5.825E6 BTU/BBL, 9.90E9 BTU OF ENERGY IS CONSUMED. 499

1225 199

THE MIXED TRAIN CONSUMES 5.64E4 GAL OF DIESEL FUEL/1.0E12 BTU 299
EQUIVALENT T OF COAL TRANSPORTED (FOOTNOTE 1218). FOR A HEAT 399
CONTENT OF 5.825E6 BTU/BBL, 7.82E9 BTU OF ENERGY IS CONSUMED. 499

1226 199

FOR HAULAGE OF COAL BY TRUCK, 9160 GAL OF DIESEL FUEL IS CONSUMED 299
FOR THE SHIPMENT OF 1.0E12 BTU EQUIVALENT T (FOOTNOTE 1219). 399
FOR A HEAT CONTENT OF 5.825E6 BTU/BBL, THE ENERGY CONSUMPTION 499

IS 1.27E9 BTU.

1227

THE ENERGY UTILIZATION BY AN AREA STRIPPING OPERATION IN THIS REGION IS ESTIMATED FROM INFORMATION IN REF. (1041,91). IT IS ASSUMED THAT FUEL AND POWER REQUIREMENTS PER T OF COAL EXTRACTED ARE INVARIANT WITH RESPECT TO ANNUAL PRODUCTION (THE DATA ON LIGNITE MINING IN THIS REGION ARE INDICATIVE, (1041, 100/116)).FOR FUEL COST AT $0.20/GAL AND POWER AT $0.015/KWH, THE TOTAL ENERGY CONSUMPTION FOR THE EXTRACTION OF 1.0E12 BTU EQUIVALENT T IS 1.96E9 BTU. WHICH IS COMPOSED OF 7.91E8 BTU OF DIESEL FUEL AND 1.14E5 KWH OF ELECTRICAL POWER. THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER USAGE TO THE FUEL CONSUMPTION. ON A 1.0E12 BTU IN BASIS THE TOTAL ENERGY CONSUMPTION IS 1.92E9 BTU.

1228

ENERGY CONSUMPTION AT A CRUSHING AND SIZING PLANT IS ABOUT 2.19E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION 1.82E5 KWH ARE ELECTRICITY AND 3.18E8 BTU ARE OIL((1064, 12A-16,39) ASSUMING ALL FUEL PURCHASED TO BE OIL AT A COST OF $0.20/GAL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMPTION TO THE OIL USAGE.

1229

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYORS FOR STORAGE AMOUNTS TO 2.08E4 KWH/1.0E12 BTU (FOOTNOTES 1058,1059, 1060). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY.

1236

STORAGE OF 1.0E12 BTU EQUIVALENT TON OF COAL ABOVE GROUND IN A PILE 30 FT HIGH REQUIRES THE USE OF 1.08 AC OF LAND. IT IS ASSUMED THAT UNDERGROUND STORAGE WILL ALSO REQUIRE THE SAME AMOUNT OF LAND.

1237

GENERALLY SILOS HAVE A DIAMETER OF 70 FT AND ARE ABOUT 150 FT IN HEIGHT. THE STORAGE CAPACITY IS APPROXIMATELY 11,000 TON (1006). THUS 5 SILOS ARE REQUIRED FOR STORING 1.0E12 BTU EQUIVALENT TON. THE LAND UTILIZED BY THE SILOS IS THEREFORE .442 ACRE.

CONTROLLED FUEL	CONTROLLED REGION
COAL	NORTHWEST

ROW	MNE-MON.	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL BTU/10^{12}BTU	13 PARTIC-ULATES	14 NO_x
			WATER POLLUTANTS (TONS/ 10^{12} BTU, EX COL 12)													
1	EXTRC	EXTRACTION														
2	SURFC	SURFACE-AREA														
3	STRP-	<10° SLOPE	0000	0.00+00 2 1231	0000	0000	0.00+00 2 1231	0.00+00 2	0.00+00 2 1231	0000	0.00+00 2	0000	0.00+00 2 1231	0000	2.39-01 4 1234	1.05+00 5 1[illegible]
4	TRNSP	TRANSPORTATION														
5	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0.00+00 2 1232	0000	0.00+00 2	0000	0000	0000	8.10-03 3 1211	2.60-01 5 1[illegible]
6	PROCS	PROCESSING														
7	BRKAR	PRIMARY BREAKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000
8	RCLEN	ROUGH CLEANING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000
9	RWSIZ	RAW COAL SIZING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	0000
10	BRKSZ	BREAKING AND SIZING	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0.00+00 1 1078	0000	0.00+00 1 1078	0000	0.00+00 2 1000	0000
11	DISTB	DISTRIBUTION														
12	UNITT	UNIT TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.37+01 6 1217	2.87+00 5 1217
13	MIXT	MIXED TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.65+01 6 1218	3.12+00 5 121[illegible]
14	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.20+01 6 1218	1.69+00 5 121[illegible]
15	STORA	COAL STORAGE														
16	AGRNE	ABOVE GROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000
17	UGRNE	UNDERGROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000
18	SILOS	SILOS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
19																
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1200 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF NORTHWESTERN COAL AND REGIONAL DESCRIPTION.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/ 10^{12} BTU	LAND (ACRE-YR/ 10^{12} BTU)	DEATHS/ 10^{12} BTU	INJURIES/ 10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	ROW
																1
																2
0000	2.39-01 4 1236	1.03+00 5 1207	7.53-02 5 1207	1.03-01 5 1207	6.26-01 5 1207	1.47-02 5 1207	2.60+00 5	7.30+02 3 1206	3.87+00 3 1230	2.50-03 1 1201	5.60-02 1 1991	1.41+00 1 1203	1001	0.00-01 1 1203	1.03+00 5 1235	3
																4
0000	6.10-03 3 1211	2.50-01 3 1211	1.80-02 3 1211	2.80-02 3 1211	1.75-01 3 1211	2.10-03 3 1211	6.00-01 3	0000	3.03-01 3 1233	0.00+00 1 1203	2.70-02 1 1993	6.74-01 1 1203	1003	1.00+00 1 1213	1.84+00 5 1215	5
																6
0000	0.00+00 2 1400	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1003	1.00+00 1 1207	0000	7
0000	0.00+00 2 1400	0000	0000	0000	0000	0000	0.00+00 2	3.42+00 4 1214	0000	0000	0000	0000	1003	1.00+00 1 1207	0000	8
0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1003	1.00+00 1 1207	0000	9
0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	3.42+00 4 1214	0.07-01 1 1210	0.00+00 2 1202	2.80-03 2 1202	1.40-01 2 1203	1002	1.00+00 1 1215	2.10+00 4 1215	10
																11
0000	2.37+01 4 1217	2.07+00 5 1217	2.32+00 5 1217	1.78-02 5 1217	2.50+00 5 1217	2.03-01 5 1217	3.34+01 4	0000	7.51-01 3 1221	7.50-02 1 1222	0.00-01 1 1222	0.50+01 2 1222	1002	1.00+00 5 1220	0.00+00 5 1220	12
0000	4.03+01 4 1218	2.12+00 5 1218	1.83+00 5 1218	1.41+00 5 1218	1.97+00 5 1218	3.10-01 5 1218	5.30+01 4	0000	7.51+01 3 1221	7.50-02 1 1222	0.00-01 1 1222	0.50+01 2 1222	1002	0.00-01 5 1220	7.52+00 5 1220	13
0000	2.20+01 4 1219	1.60+00 5 1219	1.34-01 5 1219	1.60-01 5 1219	1.03+00 5 1219	2.75-02 5 1219	2.50-01 5	0000	0.00+00 1 1007	7.74-01 5 1223	0.02-01 5 1223	6.54+01 5 1223	1002	1.00+00 5 1220	1.07+00 5 1220	14
																15
0000	0000	0000	0000	0000	0000	0000	0000	0000	1.00+00 2 1219	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	7.15+00 5 1220	16
0000	0000	0000	0000	0000	0000	0000	0000	0000	1.00+00 3 1230	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	2.15+00 5 1220	17
0000	0000	0000	0000	0000	0000	0000	0000	0000	5.42-01 3 1229	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	2.15+00 5 1220	18
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TABLE 4. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED NORTHWEST REGION OF COAL SUPPLY

FOOTNOTES FOR TABLE 4

1230

IN THE POWDER RIVER BASIN, 0.828 AC OF LAND IS OVERTURNED PER 1.0E12 BTU IN BY AREA STRIPPING AND 10 AC ARE OCCUPIED BY THE REFUSE PILE (FOOTNOTE 1205).

IN TIME AVERAGING THE LAND IMPACTS, CONSIDERATION MUST BE GIVEN TO THE EFFECTS OF RECLAMATION, WHICH IN THIS CASE IMPLIES CONTOUR BACKFILLING, REDISTRIBUTION OF TOPSOIL, SEED BED PREPARATION, TERRACING (GOUGING) AND REVEGETATION. THE CRITERION FOR REVEGETATION IS THE ESTABLISHMENT OF AN HERBACEOUS COVER SUFFICIENT TO STABILIZE THE SURFACE AGAINST EROSION. OTHER RECLAMATION PRACTICES CAN BE OCCURING SIMULTANEOUSLY.

IN THE ARID AND SEMI-ARID WEST, RECLAMATION STUDIES ARE BEING CONDUCTED. FINDINGS TO DATE ARE INCONCLUSIVE. UNDER CONTROLLED CONDITIONS (IRRIGATION, FERTILIZATION, ETC.) VEGETAL GROWTH HAVE BEEN INDUCED, BUT WHETHER THEY ARE SELF SUSTAINING AND CAPABLE OF SUPPORTING USE HAS YET TO BE PROVEN (1219 AND 1220). IT HAS BEEN CLAIMED THAT ANYWHERE FROM 5 TO 25 YRS ARE REQUIRED TO ESTABLISH A VEGETAL COVER CAPABLE OF SUPPORTING GRAZING (1021), WHILE OTHERS FEEL THAT THE ESTABLISHMENT OF A SELF SUSTAINING COVER MAY REQUIRE MORE THAN A CENTURY (1219 AND 1220).

FOR THE PURPOSES OF QUANTIFYING THE IMPACTS IT IS ASSUMED THAT 5 YRS ARE SUFFICIENT TO MEET THE ABOVE CRITERION FOR RECLAMATION. THUS, THE TIME AVERAGED LAND IMPACT IS 3.73 AC-YR/1.0E12 BTU IN (THE LAND USE FOR STORAGE OF THE SOLID WASTE IS ASSUMED TO BE ZERO, I.E., INSTANTANEOUS RECLAMATION). IT IS ASSUMED THAT 5 AC ARE REQUIRED FOR THE SETTLING BASIN, WHICH FOR A DEPTH OF 10 FT, HAS A CAPACITY OF ABOUT 16 MMGAL. THIS IS FOR A 2×10^6 TPY MINE HENCE THE LAND IMPACT IS 0.140 AC-YR/1.0E12 BTU IN.

1231

THE GROUNDWATER SEEPAGE INTO THE PIT AND THE RUNOFF FROM THE WASTE PILE ARE COLLECTED IN A SETTLING BASIN. WATER BEING A VALUABLE COMMODITY IN THIS REGION, IT IS ASSUMED THAT THE WATER IS UTILIZED FOR DUST SUPPRESSION AND IRRIGATION OF THE RECLAIMED AREAS, AS IN THE CASE FOR THE SOUTHWEST (1040). THE DISCHARGE TO THE LOCAL DRAINAGE IS NIL, THUS, THERE IS NO CONTAMINATION OF THE SURFACE WATER SUPPLY.

1232

TO CONTROL SEDIMENTATION, THE RUNOFF FROM THE HAUL ROADS IS DIVERTED TO SETTLING PONDS PLACED AT INTERVALS ALONG THE ROADWAY (1100). SINCE THE ROAD IS RELATIVELY SHORT (1.5 MI, FOOTNOTE 1204) ONLY ONE SETTLING BASIN IS ASSUMED TO BE NEEDED. BECAUSE OF THE LOW RAINFALL, THE SETTLING POND IS ASSUMED ADEQUATE TO CONTAIN ALL THE RUNOFF (FOOTNOTE 1233). THE CONTAINED WATER CAN BE UTILIZED FOR DUST SUPPRESSION OF THE HAUL ROADS OR ALLOWED TO EVAPORATE.

1233

THE HAUL ROAD LAND IMPACT IS 0.274 AC-YR/1.0E12 BTU (FOOTNOTE 1204). THE SETTLING POND IS ASSUMED TO HAVE A SURFACE AREA OF 1 AC, WHICH FOR A DEPTH OF 5 FT HAS A STORAGE CAPACITY OF 1.6 MMGAL. THUS, THE LAND IMPACT FOR THE SETTLING POND IS 0.0285 AC-YR/1.0E12 BTU (2MMT/YR HAULED ON ROADS). THE TOTAL LAND IMPACT IS 0.303 AC-YR/1.0E12 BTU.

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1234

BASED ON AN EROSION RATE OF 428 LB/AC-YR (FOOTNOTE 1207) AND A TIME AVERAGED LAND IMPACT OF 3.73 AC-YR/1.0E12 BTU IN (FOOTNOTE 1230), .798 TON PART/1.0E12 BTU IN ARE GENERATED. THIS IS IN ADDITION TO THE PARTICULATES FROM THE DIESEL FUEL CONSUMED (FOOTNOTE 1207).

1235

ASSUMING A SPOIL PILE HEIGHT OF 80 FT AND GEOMETRICALLY UNIFORM PARALLEL SPOIL BANKS RESTING AT AN ANGLE OF REPOSE OF 38 DEGREES, THE PEAK TO PEAK DISTANCE IS ABOUT A 10C FT. THUS, THE ENERGY CONSUMED TO LEVEL THE SPOIL BANKS AMOUNTS TO ABOUT 3920 HP-HR/AC((1222, 67) AND ASSUMING A 6 PC PERFORMANCE EFFICIENCY). THUS, 8.26E6 BTU/1.0E12 BTU IN ARE EXPENDED (FOOTNOTE 1205, LAND TO BE RECLAIMED). THIS ENERGY USE IS IN ADDITION TO THE ENERGY REQUIRED FOR THE MINING OPERATION - 1.92E9 BTU (FOOTNOTE 1227).

		UNCONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		FUEL	REGION														
		COAL	CENTRAL	WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL 12)													
ROW	MNE-MON	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS				SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12}BTU)	PARTIC-ULATES	NO_x
						PO_4	NO_3	OTHER	TOTAL (DS)								
1	EXTRC	EXTRACTION															
2	UNDGR	UNDERGROUND															
3	ROOMP	ROOM & PILLAR		2.02+00 5 1300	0000	0000	0000	3.41+02 5 1300	3.41+02 5	1.56+02 5 1305	0000	5.41+02 5	0000	0.00+00 1 0007	0000	0.00+00 1 1016	0.00+00 1 1[illegible]
4	SURFC	SURFACE															
5	STRIP-	<15° SLOPE		3.82+00 5 1310	0000	0000	0000	4.30+01 5 1310	4.30+01 5	4.22+00 5 1310	0000	4.72+01 5	0000	0.00+00 1 0007	0000	4.07-02 5 1300	1.42+00 5 1[illegible]
6	TRNSP	TRANSPORTATION															
7	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	2.02+01 4 1313	0000	2.02+01 4	0000	0000	0000	1.00-02 5 1316	8.40-01 5 1[illegible]
8	CONVY	CONVEYOR		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0.00+00 1 1[illegible]
9	MINRR	MINE RAIL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1003	0.00+00 2 [illegible]
10	PROCE	PROCESSING															
11	BREAK	PRIMARY BREAKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	[illegible]
12	RCLEN	ROUGH CLEANING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	[illegible]
13	RAWSZ	RAW COAL SIZING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1000	[illegible]
14	DMEDC	DENSE MEDIA (COARSE)		0000	0000	0000	0000	0.00+00 5 0000	0.00+00 5	1.50+02 4 1317	0000	1.50+02 4	0000	0.00+00 1 0007	0000	0000	[illegible]
15	BRKSZ	BREAKING & SIZING		0000	0000	0000	0000	0.00+00 2 1070	0.00+00 2	0.00+00 2 1070	0000	0.00+00 2	0000	0.00+00 1 0007	0000	0.00+00 2 1077	[illegible]
16	STEAM	STEAM COAL PLANT		2.10+01 5 1321	0000	0000	0000	4.11+01 5 1321	4.11+01 5	0.01+01 5 1321	0000	1.30+02 5	0000	0.00+00 1 0007	0000	1.74+00 5 1315	6.00-01 5 1[illegible]
17	DSTRB	DISTRIBUTION															
18	UNITT	UNIT TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.05+01 4 1322	4.17+00 5 1[illegible]
19	MIXT	MIXED TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	5.80-01 4 1320	3.42+00 5 1[illegible]
20	BARGE	RIVER BARGE		0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0[illegible]	0.00+00 2 0007	0.00+00 2 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	2.00+01 4 1320	7.94-01 4 1[illegible]
21	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.00+01 4 1320	1.40+00 4 1[illegible]
22	CONVY	CONVEYORS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	[illegible]
23	STORA	STORAGE															
24	AGRND	ABOVE GROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	[illegible]
25	UGRND	UNDERGROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	[illegible]
26	SILOS	SILO OR BIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible]
27																	
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1300 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF CENTRAL COAL AND REGIONAL DESCRIPTION.

HITTMAN

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL BTU/10^{12} BTU	PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/10^{12} BTU	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	ROW
																1
																2
0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	1.01+00 1 1300	2.50+03 2 1304	5.07+01 1 1301	5.51+01 1 1301	2.28+01 1 1301	1078	9.70-01 1 1091	4.75+00 2 1347	3
																4
0000	6.97-02 1 1309	1.42+00 5 1309	1.03-01 5 1309	1.42-01 5 1309	8.01-01 5 1309	2.10-02 5 1309	2.80+00	4.51+02 2 1306	6.99+01 2 1307	2.75+03 1 1301	1.99-01 1 1301	3.09+00 1 1301	1081	9.10-01 1 1094	6.45+00 4 1343	5
										1.11-03 1 1302	9.74-01 1 1302	9.12+00 1 1302				6
0000	1.00-01 3 1312	5.40-01 3 1312	3.84-02 3 1312	5.40-02 3 1312	3.99-01 3 1312	8.73-03 3 1312	1.02+00 3	0000	1.04-01 2 1311	0000	0000	0000	1082	1.00+00 1 1099	4.03+00 3 1344	7
0000	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0000	0.00+00 2 1012	0000	0000	0000	1083	1.00+00 1 1099	2.48+00 4 1343	8
0000	0.00+00 2 1042	0.00+00 2 1042	0.00+00 1 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0000	0.00+00 2 1042	0000	0000	0000	1082	1.00+00 1 1099	0000	9
										7.20-03 1 1303	1.71-02 1 1303	4.51-01 1 1303				10
0000	0.00+00 2 1009	0000	0000	0000	0000	0000	0.00+00 2	0.00+00 1 0997	0000	0000	0000	0000	1081	1.00+00 1 1007	1.03+00 2 1349	11
0000	0.00+00 2 1009	0000	0000	0000	0000	0000	0.00+00 2	3.83+00 4 1316	0000	0000	0000	0000	1082	1.00+00 1 1007	0000	12
0000	0.00+00 2 1009	0000	0000	0000	0000	0000	0.00+00 2	0.00+00 1 0997	0000	0000	0000	0000	1082	1.00+00 1 1007	0000	13
0000	0000	0000	0000	0000	0000	0000	0000	7.22+03 2 1317	0000	0000	0000	0000	1083	8.52-01 2 1316	0000	14
0000	0.00+00 2 1077	0000	0000	0000	0000	0000	0.00+00 2	2.83+00 4 1316	2.52-01 5 1320	0000	0000	0000	1083	1.00+00 1 1006	1.03+00 4 1345	15
0000	1.74+00 5 1315	4.80-01 5 1315	2.30+00 5 1315	2.08-01 5 1315	5.21+00 5 1315	0000	1.12+01 5	4.12+03 2 1316	2.03+00 2 1316	0000	0000	0000	1082	9.73-01 2 1340	2.62+00 4 1341	16
																17
0000	2.03+01 4 1322	4.17+00 3 1322	3.70+00 3 1322	2.03+00 3 1322	2.09+00 3 1322	8.28-01 3 1322	3.56-01 3	0000	3.04+01 3 1324	8.63-02 3 1325	8.70-01 3 1325	8.15+01 3 1325	1082	.00+00 2 1348	1.58+10 [illegible] 1325	18
0000	5.80+01 4 1328	3.62+00 5 1328	2.00+00 5 1328	2.28+00 5 1328	2.18+00 5 1328	5.02-01 5 1328	5.12+01 5	0000	3.04+01 3 1324	8.02-02 3 1325	8.70-01 3 1325	8.12+01 3 1325	1082	8.92-01 2 1348	1.28+10 5 1325	19
0.00+00 1 0007	2.00+01 4 1329	7.94-01 4 1329	8.50-01 4 1329	5.06-01 4 1329	4.70-01 4 1329	4.04-02 4 1329	2.20+01 4	0000	0000	1.83-02 5 1329	3.21-02 5 1329	2.43-01 5 1329	1082	1.00+00 2 1348	6.04+00 6 1330	20
0000	1.00+01 4 1330	1.40+00 4 1330	1.04-01 4 1330	1.40-01 4 1330	8.06-01 4 1330	2.31-02 4 1330	2.15+01 4	0000	1.04+00 2 1332	3.34-02 5 1327	6.02-01 5 1327	4.54+01 5 1327	1082	1.00+00 2 1348	1.07+00 4 1331	21
0000	0.00+00 1 1012	0000	0000	0000	0000	0000	0.00+00 1	0000	4.20-01 3 1335	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1082	1.00+00 2 1348	6.18+00 6 1330	22
																23
0000	0000	0000	0000	0000	0000	0000	0000	0000	8.70-01 2 1337	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1082	7.90-01 2 1097	1.78+00 5 1330	24
0000	0000	0000	0000	0000	0000	0000	0000	0000	8.70-01 2 1337	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1082	9.00-01 2 1097	1.78+00 5 1330	25
0000	0000	0000	0000	0000	0000	0000	0000	0000	8.41-01 2 1336	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1082	9.03-01 2 1097	1.78+00 5 1330	26
																27
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TABLE 5. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED CENTRAL REGION OF COAL SUPPLY

FOOTNOTES FOR TABLE 5

1300

THE CENTRAL REGION FOR THIS STUDY IS COMPRISED OF THE STATES OF ILLINOIS AND INDIANA. THE AVERAGE CALORIC CONTENT OF COAL DELIVERED TO ELECTRIC UTILITIES IN THIS REGION DURING THE 3RD AND 4TH QUARTERS OF 1972 WAS ABOUT 10600 BTU/LB AND THE AVERAGE SULFUR CONTENT WAS APPROXIMATELY 2.92 PC(1212 AND 1213). THE AVERAGE ASH CONTENT OF COAL MINED IN INDIANA AND ILLINOIS IS ABOUT 8.9 PC(1026). THE DENSITY OF THE COAL IS 81 LB/CF.

FOR THE GIVEN HEAT VALUE 1.0E12 BTU IS EQUIVALENT TO 47200 T. ALTHOUGH ILLINOIS PRODUCED 7.3P OF THE METALLURGICAL COAL CONSUMPTION IN 1971 (1036), IT IS NOT CONSIDERED IN THIS ANALYSIS. ONLY STEAM RAISING COAL IS STUDIED.

1301

THE OCCUPATIONAL HEALTH IMPACTS DUE TO THE MINING OF CENTRAL COAL WERE BASED ON STATISTICS IN REFERENCE (1206-1210).

THE NUMBER OF FATALITIES AND NON-FATALITIES AND COAL PRODUCTION QUANTITIES WERE TABULATED FOR UNDERGROUND AND STRIP MINES,AND AVERAGES OBTAINED OVER THE FIVE YEARS OF RECORD. THEREFORE, FOR DEEP MINING, THERE RESULTS 0.222 FATALITIES / 1.0E6 TONS PRODUCTION AND 23.1 NON-FATALITIES (INJURIES) / 1.0E6 TONS PRODUCTION.FOR SURFACE (STRIP) MINING , 0.072 FATALITIES / 1.0E6 TONS PRODUCTION AND 4.19 NON-FATALITIES / 1.0E6 TONS PRODUCTION RESULT.

THE MAN-DAYS LOST PER INJURY QUANTITIES RESULT FROM AVERAGE SEVERITY STATISTICS FOR BOTH UNDERGROUND AND STRIP MINING. FOR EACH MINING MODE, AVERAGING WAS PERFORMED BETWEEN THE TWO STATES AND OVER THE FIVE YEARS OF RECORD. AVERAGE SEVERITY QUANTITIES WERE USED BASED ON THE NUMBER OF TEMPORARY TOTAL DISABILITIES. AS A RESULT OF DEEP MINING, 36.4 WORK-DAYS-LOST / INJURY WAS DERIVED. FOR STRIP OR SURFACE MINING, 24.9 WORK -DAYS WERE LOST PER INJURY.

1302

THE INJURY STATISTICS DUE TO HAULAGE FOR THE TWO TYPES OF MINING, UNDERGROUND AND STRIP, WERE COMBINED. AVERAGING WAS PERFORMED BETWEEN THE TWO STATES, ILLINOIS AND INDIANA, AND OVER THE FIVE YEARS OF RECORD. AVERAGES OF 0.0236 FATALITIES / 1.0E6 TONS PRODUCTION AND 1.64 NON-FATALITIES / 1.0E6 PRODUCTION WERE COMPUTED FOR COAL HAULAGE.

AN APPROXIMATE AVERAGE OF 30 WORK-DAYS LOST PER INJURY IS DETERMINED FOR TRANSPORT FOLLOWING EITHER DEEP OR SURFACE MINING. THIS QUANTITY RESULTS FROM AVERAGING THE TWO VALUES REPORTED IN FOOTNOTE 1301. THE REPORTED STATISTICS ON AVERAGE SEVERITIES WERE COMPRISED OF CONTRIBUTIONS DUE TO EXTRACTION AND HAULAGE. THE RELATIVE CONTRIBUTION OF EACH CANNOT BE ISOLATED.

1303

THE INJURY STATISTICS UNDER MECHANICAL CLEANING OR COAL PREPARATION PLANTS FOR ILLINOIS AND INDIANA WERE EMPLOYED. IN THE YEARS 1964-1966 AND 1968,NO FATALITIES WERE REPORTED. IN 1969, ONE FATALITY WAS REPORTED IN ILLINOIS. THUS AN AVERAGE OF 0.00154 FATALITIES / 1.0E6 TONS PRODUCTION RESULTED. FOR THESE TWO STATES AN AVERAGE OF 0.363 NON-FATALITIES / 1.0E6 TONS PRODUCTION WAS COMPUTED TO OCCUR AT MECHANICAL CLEANING PLANTS.

AVERAGE SEVERITY STATISTICS FOR MECHANICAL CLEANING PLANTS HAVE ONLY BEEN REPORTED IN THE MORE RECENT REPORTS . MAN-DAYS LOST PER INJURY COULD ONLY BE OBTAINED FROM AVERAGING THE

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STATISTICS FOR THE YEARS 1966, 1968, AND 1969. FOR THE STATES OF ILLINOIS AND INDIANA AN AVERAGE OF 26.3 WORK-DAYS LOST PER INJURY (TEMPORARY TOTAL DISABILITY) WAS COMPUTED.

1304

THE AVERAGE THICKNESS OF COAL SEAMS MINED UNDERGROUND IN THIS REGION IN 1965 WAS 6.8 FT (1017). THUS, FOR 1.0E12 BTU EQUIVALENT T,3.93 AC IS UNDERMINED.
OF THE ACREAGE UNDERMINED APPROXIMATELY 25P WILL SUBSIDE (1019). THIS SUBSIDENCE RATE IS ACTUALLY FOR ALL UNDERGROUND COAL MINES, BUT SINCE THE ROOM & PILLAR TECHNIQUE HAS BEEN PREDOMINANT IN THE U.S., IT IS ASSUMED THAT THIS FIGURE CHARACTERIZES THE SUBSIDENCE FOR ROOM & PILLAR MINING. EVENTUALLY ALL OF THE AREA UNDERMINED MAY SUBSIDE, BUT THE TIME SCALE IS IN EXCESS OF A CENTURY. THE 25P SUBSIDENCE RATE IS DERIVED FROM HISTORICAL OBSERVATIONS.

SUBSIDENCE AFFECTS A SURFACE AREA GREATER THAN THE AREA UNDERMINED. THE WIDTH ON THE PERIMETER THAT IS AFFECTED BY SUBSIDENCE IS DETERMINED FROM

$$R=H \tan X$$

WHERE, R=WIDTH OF THE PERIMETER AREA AFFECTED, H=DEPTH OF MINE, AND X=ANGLE OF DRAW (ANGLE BETWEEN A VERTICAL LINE, AND A LINE CONNECTING THE FACE AND THE LIMIT OF SUBSIDENCE). THE ANGLE OF DRAW HAS BEEN CONSISTENTLY OBSERVED IN EUROPEAN COAL FIELDS TO FALL BETWEEN 35-39 DEGREES (1027,232,233). THUS, FOR AN ANGLE OF DRAW OF 37 DEGREES AND A MINE DEPTH OF 600 FT, THE WIDTH OF THE AFFECTED PERIMETER AREA IS 452 FT.
OF THE AREA UNDERMINED .984 AC SUBSIDES. ASSUMING A SQUARE AREA THE SIDES ARE 207 FT IN LENGTH. THUS, AN ADDITIONAL 8.59 AC ARE AFFECTED BY SUBSIDENCE. TIME AVERAGING (OVER 25 YR OF THE MINE LIFE EXPECTENCY) THE ACREAGE AFFECTED BY SUBSIDENCE, THE LAND IMPACT IS 120 AC-YR/1.0E12 BTU IN.

IN A PILE 30 FT HIGH, 4.59E-2 AC OF LAND IS OCCUPIED BY THE REFUSE PILE (FOOTNOTE 1306, SOLID WASTE PRODUCTION). THE AVERAGE ANNUAL PRODUCTION FROM SIZABLE UNDERGROUND MINES IS ABOUT 2 MMT (1005,90). HENCE, THE LAND (FIXED) UTILIZED FOR STORAGE IS 6.16E-4 AC-YR/1.0E12 BTU IN.

1305

ACID MINE DRAINAGE IS NOT A SERIOUS PROBLEM IN THIS REGION, SINCE MOST OF THE MINES ARE LOCATED BELOW DRAINAGE AND IN SOME CASES THE OVERBURDEN IS ALKALINE IN CONTENT (1008,1009 AND 1105). THE DRAINAGE PROBLEM IS PRIMARILY ONE OF DISPOSING THE SEEPAGE WATER FROM ACTIVE WORKINGS, WHICH COULD BE ACIDIC IN NATURE. SINCE NO WATER QUALITY DATA ARE AVAILABLE FOR THIS REGION, THE ACID YIELD IS ASSUMED TO BE 5 PC OF THE YIELD IN APPALACHIA (THE MILES OF STREAMS AFFECTED BY ACID POLLUTION IN ILLINOIS AND INDIANA AMOUNT TO 5 PC OF THE MILES OF POLLUTED STREAMS IN APPALACHIA (1301,122)), I.E., 7.50E-5 T OF ACIDITY/T OF COAL EXTRACTED FROM UNDERGROUND MINES (FOOTNOTE 1018). THE SULFATE LOADING IS TWICE AS MUCH AS THE ACID LOADING AND THE MINERAL COMPOSITION IS ASSUMED TO BE THE SAME AS FOR APPALACHIA. THUS, THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	T/1.0E12 BTU IN
HARDNESS	328.0
FE	5.76
MN	2.44

AL	.724	2199
SO4	4.04	2299
TOTAL	341.0	2399
		2499
ACIDITY	2.02	2599
		2699

IT SHOULD BE NOTED THAT SIGNIFICANT QUANTITIES OF CHLORIDE 2799
ARE FOUND IN THE MINE DRAINAGE OF THIS REGION. 2899
THE SEDIMENT YIELD FROM THE WASTE PILE OCCURS AT A RATE OF 2999
2.54 T/AC-YR-IN. OF RUNOFF (COMPUTED FROM INFORMATION IN 3099
(1020)). THUS, FOR A RUNOFF OF 10 IN., THE SEDIMENT YIELD IS 3199
.0156 T/1.0E12 BTU IN (FOOTNOTE 1304, LAND USE BY WASTE PILE). 3299
THE APPALACHIAN DATA ARE USED ABOVE BECAUSE OF THE LACK OF 3399
ADEQUATE DATA FROM THE CENTRAL REGION. 3499

1306 199

SOLID WASTE PRODUCTION AT UNDERGROUND MINES IS IN GENERAL RELATED 299
TO THE OPENING OF THE MINE. ASSUMING AN AVERAGE MINE DEPTH OF 399
600 FT (WHICH IS THE AVERAGE FOR ILLINOIS (1016)) AND A SHAFT 499
OPENING OF 100 SF, 3000 T OF EARTH IS REMOVED TO SINK THE 599
SHAFT. FURTHER ASSUMING AN AVERAGE PRODUCTION OF 50 MMT PER 699
MINE, THE PRODUCTION OF SOLID WASTE OCCURS AT A RATE OF 60E-6 799
T/T OF COAL MINED. HENCE, 1.61 T OF SOLID WASTE IS PRODUCED 899
PER 1.0E12 BTU IN. 999

1307 199

THE AVERAGE THICKNESS OF COAL SEAMS STRIP MINED IN 1965 WAS 4.8 299
FT (1017,6). THUS, 5.57 AC OF LAND ARE OVERTURNED FOR EACH 399
1.0E12 BTU IN. THE TIME AVERAGED (OVER 25 YR OF MINE LIFE 499
EXPECTENCY) LAND IMPACT IS THEREFORE 69.7 AC-YR/1.0E12 BTU IN. 599
THE LAND OCCUPIED BY THE SOLID WASTE PILE 30 FT HIGH IS 8.66 699
AC OR, FOR A PRODUCTION RATE OF 2 MMT/YR, 0.166 AC-YR/1.0E12 799
BTU IN (FOOTNOTE 1308, SOLID WASTE PRODUCTION). 899

1308 199

THE MEAN OVERBURDEN DEPTH IS 52 FT (1017). IN SURFACE MINING ALL 299
OF THE OVERBURDEN, EXCEPT THAT WHICH IS REMOVED DURING THE BOX 399
CUT, IS DEPOSITED IN SPOIL BANKS IN THE EXCAVATED AREA. HENCE, 499
THE SOLID WASTE IS PRODUCED ONLY DURING THE OPENING OF THE 599
MINE. ASSUMING THAT ON THE AVERAGE FIVE ACRES (PIT SIZE OF 699
ROUGHLY 100 FEET BY 2000 FEET (1007)) ARE EXCAVATED FOR THE 799
BOX CUT AND 50 MILLION TONS OF COAL ARE CONSEQUENTLY 899
EXTRACTED, THE SOLID WASTE (566,000 TONS OF EARTH) PRODUCTION 999
IS 433 TONS /1.0E12 BTU IN. 1099

1309 199

A MAJORITY (59 PC) OF THE EXCAVATING EQUIPMENT IN THIS REGION ARE 299
ELECTRICALLY POWERED (1004,38), BUT THE SUPPORTING EQUIPMENT 399
IS DIESEL FIRED. 499
AN AREA STRIPPING OPERATION CONSUMES ABOUT 7650 GAL OF DIESEL 599
FUEL PER 1.0E12 BTU IN (FOOTNOTE 1343). THE EMISSION 699
FACTORS ARE OBTAINED FROM REF. (0002,3-7) ASSUMING THE CHAR- 799
ACTERISTICS OF A DIESEL TRUCK ENGINE. SINCE ADEQUATE MOISTURE 899
IS AVAILABLE IN THIS REGION THE FUGITIVE DUST PROBLEM SHOULD 999
NOT BE SERIOUS. 1099

1310 199

DUE TO THE LACK OF ADEQUATE DATA IN THE CENTRAL REGION, THE 299
DRAINAGE FROM STRIP MINES IS ASSUMED TO BE THE SAME AS 399
FOR CENTRAL APPALACHIA (FOOTNOTE 1514). THE ACIDITY OCCURS 499
AT A RATE OF 10.7 T/DAY, OR 1.0E-4 T/T OF COAL EXTRACTED. THE 599
SULFATE LOADING IS TWICE THE ACID LOAD. THE EFFLUENT BREAKDOWN 699
IS AS FOLLOWS 799

	T/1.0E12 BTU IN	899
HARDNESS	34.4	999

FTN. 1311-1316

FE	.604	
MN	.255	
AL	.0757	
SO4	7.64	
TOTAL	43.0	
ACIDITY	3.82	

IT SHOULD BE NOTED THAT SIGNIFICANT QUANTITIES OF CHLORIDE ARE FOUND IN THE MINE DRAINAGE OF THIS REGION.
THE SEDIMENT YIELD FROM THE SPOIL PILES OCCURS AT A RATE OF 2.54 T/AC-YR-IN. OF RUNOFF (FOOTNOTE 1305). THUS, FOR A RUNOFF OF 10 IN., THE SEDIMENT YIELD IS 4.22 T/1.0E12 BTU IN (FOOTNOTE 1307).

1311

THE DATA FROM STUDIES CONDUCTED IN EASTERN KENTUCKY (1024,1031, 1032,1033,1034) INDICATE AN AVERAGE HAULAGE ROAD RIGHT-OF-WAY OF 53 FT (6.4 AC/MI). THE MEAN DISTANCE FROM MINE TO TIPPLE IS 3.8 MI (C001,334). HENCE, 24.3 AC OF LAND IS UTILIZED BY THE ROADS. ASSUMING AN ANNUAL PRODUCTION FROM THE MINE OF 2 MMT (FOOTNOTE 1022), 2.4P OF THE HAULAGE ROAD USAGE IS ATTRIBUTED TO THE TRANSPCRT OF 1.0E12 BTU EQUIVALENT T. THE LAND IMPACT IS THEREFORE 0.584 AC-YR/1.0E12 BTU.

1312

IN 1969 THE AVERAGE TRUCK CAPACITY FOR THIS REGION WAS 59 T AND THE AVERAGE HAULAGE DISTANCE FROM MINE TO TIPPLE WAS 3.8 MI (0001,344). THE FUEL CONSUMPTION RATE IS ASSUMED TO BE 7 GAL/ 1000 TMI (0002,3-7). ASSUMING A GROSS TO TARE WEIGHT RATIO OF 2.5 TO 1 FOR THE TRUCKS, A ROUND TRIP IS 520 TMI. SINCE 800 ROUND TRIPS ARE REQUIRED TO HAUL 1.0E12 BTU EQUIVALENT T, 2920 GAL OF DIESEL FUEL ARE CONSUMED.THE EMISSIONS BREAKDOWN FOR A DIESEL POWERED TRUCK IS GIVEN IN REF. (0002,3-7).
DUSTING FROM HAULAGE ROADS ARE CONTROLED BY WATERING DOWN, OILING OR SCME OTHER METHOD.

1313

IN AN EASTERN KENTUCKY STUDY THE SEDIMENT YIELD FROM A COAL HAUL ROAD WAS DETERMINED TO BE 90 T/AC-YR (1020,C32). THIS STUDY WAS CONDUCTED FOR AN ABANDONED MINE AND FOR A RELATIVELY STEEP SLOPING AREA. THUS, SILTATION WAS EXCEPTIONALLY HIGH. FOR THE PRESENT COMPUTATION IT IS ASSUMED THAT THE SEDIMENT YIELD AVERAGES TO 35 T/AC-YR. HENCE, 20.2 T/1.0E12 BTU OF SEDIMENT IS YIELDED (FOOTNOTE 1311).

1314

IT IS ASSUMED THAT .006PC OF THE FEED TO THE PREPARATION PLANT IS REMOVED AS TRAMP IRON. HENCE, 2.83 T OF TRAMP IRON IS COLLECTED FOR EVERY 1.0E12 BTU EQUIVALENT T PROCESSED. THE PERCENTAGE OF TRAMP IRON IS ESTIMATED FROM INFORMATION IN REF. (1059,6-31), ASSUMING THAT THE LARGE PLANT PROCESSES 1000 COAL T/HR.

1315

MANY REFUSE BANKS ARE FOUND BURNING OR SMOLDERING IN ILLINOIS AND INDIANA (1067). THUS, THE WASTE PILE IS ASSUMED TO BE BURNING. THE EMISSION FACTORS ARE OBTAINED FROM REF. (0017). (FOOTNOTE 1318. SOLID WASTE PRODUCTION).

1316

THE BTU EFFICIENCY OF WASHING, I.E., THE RATIO OF THE CALORIC CONTENT OF THE INPUT COAL AND THE OUTPUT COAL MULTIPLIED BY THE YIELD, DEPENDS ON THE ASH CONTENT OF THE FEED COAL AS WELL AS THE SPECIFIC GRAVITY OF THE WASH AND THE SIZE DISTRIBUTION WASHED. THUS, TO CALCULATE A FIRM NUMBER REQUIRES THE KNOWLEDGE OF THE ASH CONTENT OF THE R.O.M. COAL AND THE SPECIFIC GRAVITY OF THE BATH. FROM THE AVERAGED DATA IN REF. (1010)

THE EQUATION FOLLOWING HAS BEEN DEVELOPED FOR A SPECIFIC GRAVITY OF WASHING OF 1.6

PC BTU EFFICIENCY = -0.342 (PC ASH) + 100

THUS, FOR AN ASH CONTENT OF 14.1PC(1053,13) THE EFFICIENCY IS 95.2 PC.

1317

THE DENSE MEDIUM BATH IS ASSUMED TO BE WASHING AT A SPECIFIC GRAVITY OF 1.6, AS FOR THE STEAM COAL PREPARATION PLANT (FOOTNOTE 1318). THE FEED TO THE BATH IS 1.5 X 3/8 IN SIZE COAL AND IS ASSUMED TO HAVE THE CHARACTERISTICS OF THE AVERAGE UTILITY COAL FOR THIS REGION, I.E., 14.1P ASH AND 3.92P TOTAL SULFUR (THIS AVERAGE INCLUDES COAL FROM WEST KENTUCKY, (1053,13)). THE WASHABILITY DATA FOR THE NO. 9 COALBED IN HOPKINS COUNTY, KENTUCKY IS USED FOR THIS ANALYSIS (1053,71).
THE AVERAGE RECOVERY EFFICIENCY FOR DENSE MEDIUM VESSELS IS ABOUT 97P (1054). THUS, THE YIELD AT A WASH SPECIFIC GRAVITY OF 1.6 IS ESTIMATED TO BE 84.5P WHICH IMPLIES A SOLID WASTE PRODUCTION OF 7316 T/1.0E12 BTU EQUIVALENT T OF COAL PROCESSED.
THE SCREEN ANALYSIS FOR THIS COAL INDICATE THAT 3.3P OF THE 1.5 X 0 IN. CRUSHED COAL IS CONTAINED IN THE SIZE FRACTION LESS THAN 100 MESH (1055) IT IS ASSUMED THAT 10P OF THIS SIZE FRACTION ENDS UP AS BLACKWATER DISCHARGE. THUS, 156 T OF COAL FINES ARE DISCHARGED AS SUSPENDED SOLIDS FOR EVERY 1.0E12 BTU EQUIVALENT T OF COAL PROCESSED.
MAGNETITE LOSSES AMOUNT TO 0.9 LB/T OF CLEAN COAL PRODUCED. THUS, AN ADDITIONAL 18 T OF SOLID WASTE IS PRODUCED.

1318

THE PREPARATION PLANT PROCESSES 500 T/HR OF R.O.M. COAL. THE COAL IS CRUSHED TO 1.5 IN. TOPSIZE. THE 1.5 X 3/8 IN. SIZE FRACTION IS WASHED IN A DENSE MEDIUM VESSEL AT A SPECIFIC GRAVITY OF 1.6, WHILE THE COAL LESS THAN 3/8 IN. IN SIZE IS NOT SUBJECTED TO ANY CLEANING.
THE WASHABILITY DATA FOR THE NO. 9 COALBED IN HOPKINS COUNTY, KENTUCKY (1053,71) ARE USED FOR THIS ANALYSIS SINCE THE CHARACTERISTICS OF THIS COAL ARE SIMILAR TO THE AVERAGE UTILITY COAL FOR THIS REGION, I.E., 14.1P ASH AND 3.92P TOTAL SULFUR (1053,13).
THE SCREEN ANALYSIS OF THIS COAL INDICATE THAT 44 P OF THE CRUSHED COAL IS LESS THAN 3/8 IN. IN SIZE.
THUS, 280 T/HR OF 1.5 X 3/8 IN. SIZE FRACTION IS FED TO THE DENSE MEDIUM BATH.
THE WASHABILITY DATA INDICATE A THEORETICAL RECOVERY OF 87.1P. FOR A RECOVERY EFFICIENCY OF 97P (1054), THE ACTUAL WASHED COAL RECOVERY IS 84.5P. THIS IMPLIES THAT FOR EVERY 1.0E12 BTU EQUIVALENT T OF COAL FED TO THE PREPARATION PLANT, 4115 T OF REFUSE ARE GENERATED.
MAGNETITE LOSSES AMOUNT TO 0.9 LB/T OF CLEAN COAL OUTPUT FROM THE BATH (1054). THUS AN ADDITIONAL 10.1 T/1.0E 12 BTU OF SOLID WASTE ARE PRODUCED. THE COLLECTING OF TRAMP IRON AMOUNTS TO 2.83 TON/1.0E12 BTU (FOOTNOTE 1314).

1319

THE LAND REQUIRED FOR THE PREPARATION PLANT IS ABOUT 5 AC (1008). THE LOADING AREA FOR A 10000 T UNIT TRAIN IS ESTIMATED TO BE ABOUT 40 AC (DATA ON THE MATTHEWS MINE, (1006,85)) AND THE SETTLING POND OCCUPIES ABOUT 50 AC (1009). THE PLANT PROCESSES 2 MMT/YR, THUS THE LAND IMPACT IS 2.24 AC-YR/1.0E12 BTU.
IN A PILE 30 FT HIGH THE REFUSE (FOOTNOTE 1318) OCCUPIES 0.0632 AC/1.0E12 BTU. THE TIME AVERAGED (OVER THE 25 YR LIFE EXPECTENCY OF THE PLANT) LAND IMPACT IS 0.791 AC-YR/1.0E12

BTU.

1320

APPROX. 35 ACRES OF LAND ARE UTILIZED FOR THE PREPARATION PLANT AND A 10000 T UNIT TRAIN LOADING FACILITY (1021). THUS, THE LAND IMPACT IS ABOUT 0.826 AC-YR/1.0E12 BTU.
IT IS ASSUMED THAT THE MODES OF TRANSPORT OTHER THAN UNIT TRAINS HAVE SIMILAR LAND REQUIREMENTS.
AT A CRUSHING AND SIZING PLANT, NO SIGNIFICANT SOLID WASTE IS GENERATED. THUS ADDITIONAL LAND REQUIRED FOR STORAGE IS NEGLIGIBLE.

1321

THE SEEPAGE FROM THE REFUSE PILE IS ASSUMED TO OCCUR AT A RATE OF 1670 GAL/AC-DAY AND CONTAINS 0.091 LB OF ACIDITY/GAL, 0.144 LB SULFATE/GAL, 0.0258 LB IRON/GAL AND 3.78E-4 LB MANGANESE/GAL (1009). THE DISCHARGE IS THEREFORE CONSTITUTED AS FOLLOWS

	T/1.0E12 BTU IN
FE	6.2
SO4	34.8
MN	0.1
TOTAL	41.1
ACIDITY	21.9

THE SEDIMENT YIELD FROM THE REFUSE PILE IS 20.1 T/1.0E12 BTU (FOOTNOTE 1310). (SEE FOOTNOTE 1319 FOR LAND USE BY THE REFUSE PILE).
OF THE RAW CRUSHED COAL 3.3PC IS LESS THAN 100 MESH IN SIZE (1055). A PROPORTION OF THIS SIZE FRACTION ENDS UP IN THE FEED TO THE DENSE MEDIUM CIRCUIT. ASSUMING 10 PC OF THE COAL LESS THAN 100 MESH IN SIZE IS YIELDED AS BLACKWATER DISCHARGE, SUSPENDED SOLIDS ARE GENERATED AT A RATE OF 1.65 T/HR. IT IS UNREALISTIC TO ASSUME THAT ALL OF THE BLACKWATER IS DISCHARGED TO THE NATURAL DRAINAGE SINCE SOME PLANTS DO HAVE CONTROLS. IN INDIANA AND ILLINOIS ABOUT 50P OF THE PLANTS HAVE SOME TREATMENT FACILITY (1073). THUS IT IS ASSUMED THAT 50P OF THE BLACKWATER GENERATED, 0.825 T/HR, IS DISCHARGED TO THE NATURAL DRAINAGE THROUGH LEAKS, OVERFLOWS AND IMPROPER SETTLING. SUSPENDED SOLIDS ARE THEREFORE DISCHARGED AT A RATE OF 78.0 T/1.0E12 BTU.

1322

ENERGY CONSUMPTION BY FREIGHT TRAINS, ASSUMED TO APPLY AS WELL TO UNIT TRAINS, IS 690 BTU/TMI (FOOTNOTE 7013), OR 0.005 GAL OF DIESEL FUEL/TMI (5.83E6 BTU/BBL, (0005,38)). AN ALL STEEL HOPPER CAR WITH A CAPACITY OF 70 T HAS A GROSS TO TARE WEIGHT RATIO OF ABOUT 4 TO 1 (0023,1136). IT IS ASSUMED THAT THIS FIGURE HOLDS FOR 100 T CARS AND THAT THE FUEL CONSUMPTION PER TRAIN IS AS CITED ABOVE. FROM DATA IN (0021,31) THE ENERGY CONSUMPTION ASSUMES AN AVERAGE USAGE OF 3 LOCOMOTIVES PER TRAIN. IN GENERAL A UNIT TRAIN HAULS 10,000 TON COAL PER TRIP (1005,33).
THE AVERAGE HAULAGE DISTANCE FOR 3 UNIT TRAINS STUDIED BY THE BUR OF MINES IS ABOUT 290 MI (1006,10). THIS IS ALSO THE APPROXIMATE DISTANCE BETWEEN CHICAGO AND THE SOUTHERN AREA OF ILLINOIS WHERE MOST OF THE COAL IN THIS REGION IS MINED. ASSUMING 290 MI AVERAGE HAULAGE DISTANCE FOR THIS REGION, FUEL CONSUMPTION IS 24200 GAL PER ROUND TRIP OR 1.14E5 GAL/1.0E12 BTU. THE EMISSION FACTORS ARE COMPUTED FROM (0002,3-7).
WINDAGE LOSSES, ASSUMED TO BE AIRBORNE AS PARTICULATES, ARE ABOUT .04 PC OF THE TONNAGE HAULED. SINCE THE LOSSES OCCUR MAINLY DURING HANDLING AT EITHER END POINT, THEY ARE ESSENTIALLY INDEPENDENT OF THE HAULAGE DISTANCE. THUS, 18.9 T OF COAL FINES ARE RELEASED AS PARTICULATES FOR EACH 1.0E12 BTU EQUIVALENT T HAULED.

1323

CONSUMPTION OF DIESEL FUEL AMOUNTS TO 1.14E5 GAL/1.0E12 BTU (FOOT- 299
NOTE 1322). THUS, THE ENERGY CONSUMPTION IS 1.58E 10 BTU. 399

1324 199

THE AVERAGE MILES OF RAILROAD OPERATED IN THE EASTERN DISTRICT 299
(DIVISIONS MADE BY ICC,(0033,II)) IS 54000 MI (0033,59). THUS, 399
FOR A RIGHT-OF-WAY OF 6 AC/MI (FOOTNOTE 1027) THE TOTAL LAND 499
USAGE IS 324,000 AC. 599
OF THE TOTAL TONNAGE OF FREIGHT HAULED IN 1971 214E06 TON 699
WERE COAL, OR 43 PC. OF THIS 4.96E06 TON OR 2.32 PC ORIGI- 799
NATED FROM ILLINOIS AND INDIANA (0039,27 AND 1004,52,53). 899
HENCE, 30.4 AC-YR/1.0E12 BTU IS ATTRIBUTED TO THE HAULAGE 999
OF COAL FROM ILLINOIS AND INDIANA. 1099

1325 199

IN THE EASTERN DISTRICT RAILWAY ACCIDENTS CLAIMED 705 LIVES, 299
INJURED 9304 PERSONS (0006,17,54) AND AN AVERAGE OF 93 MAN- 399
DAYS WERE LOST PER INJURY (0006,4). 499
OF THE TOTAL KILLED AND INJURED 0.0663 FATALATIES AND 0.876 599
NON-FATAL INJURIES ARE ATTRIBUTED TO THE TRANSPORT OF 1.0E12 699
BTU EQUIVALENT T FROM ILLINOIS AND INDIANA. FOR THE SAME 799
HAULAGE 81.3 MAN-DAYS ARE LOST. (FOOTNOTE 1324, COAL 899
TRANSPORTED IN 1971). 999

1326 199

THE INJURY STATISTICS ARE NATIONAL AVERAGES (FOOTNOTE 1063). NO 299
REGIONAL DATA HAVE BEEN LOCATED. 399

1327 199

THE INJURY STATISTICS ARE NATIONAL AVERAGES (FOOTNOTE 1061). NO 299
REGIONAL DATA HAVE BEEN LOCATED. 399

1328 199

THE AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 290 MI AND FUEL 299
CONSUMPTION IS 0.005 GAL/TMI (FOOTNOTE 1322). ASSUMING 1000 399
TONS ARE CARRIED PER TRIP & COAL ACCOUNTS FOR 20PC OF THE 499
TONNAGE OF ANY ONE SHIPMENT, A GROSS TO TARE WEIGHT RATIO 599
OF 4 TO 1 AND ONLY ONE WAY DIESEL FUEL CONSUMPTION ATTRIBUTED 699
TO COAL, 1930 GAL OF DIESEL FUEL CONSUMED PER TRIP ARE 799
ATTRIBUTED TO THE SHIPMENT OF THE COAL OR 9.12E4 GAL/1.0E12 899
BTU. THE EMISSIONS ARE COMPUTED FROM INFORMATION ON DIESEL 999
LOCOMOTIVES IN (0002,3-7). 1099
THE WINDAGE LOSSES ARE ASSUMED TO BE APPROXIMATELY .08 PC OF 1199
THE TOTAL SHIPMENT. HENCE, ABOUT 37.8 T ARE RELEASED TO THE 1299
ATMOSPHERE AS PARTICULATES. (MOST OF THESE LOSSES OCCUR 1399
DURING HANDLING AT EITHER END POINT.) 1499

1329 199

THE AVERAGE CAPACITY OF A BARGE IS 25000 T (1005,34), AND THE 299
AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 300 MI (THE APPRO- 399
XIMATE DISTANCE FROM THE SOUTHERN COAL FIELDS OF ILLINOIS TO 499
CHICAGO VIA THE ILLINOIS RIVER). THE EMISSION IS CALCULATED 599
FROM DATA ON MOTORSHIPS UNDERWAY IN (0002,3-11). 699
THE WINDAGE LOSSES, OCCURING MAINLY FROM HANDLING AT THE 799
ORIGIN AND TERMINAL POINTS, ARE ASSUMED TO BE .04 PC OF THE 899
TOTAL SHIPMENT AS IN THE CASE FOR UNIT TRAINS. THUS, 18.9 T OF 999
COAL FINES ARE EMITTED AS PARTICULATES. 1099

1330 199

WHEN TRUCKS ARE UTILIZED IT IS USUALLY FOR SHORT HAULAGE DISTANCES 299
THAT AVERAGES ABOUT 10 MI (1013). ASSUMING AN AVERAGE TRUCK 399
CAPACITY OF 20 T, A GROSS TO NET WEIGHT RATIO OF 2.5 TO 1, AND 499
A FUEL CONSUMPTION RATE OF 7 GAL/1000 TMI, 7700 GAL OF DIESEL 599
FUEL IS CONSUMED/1.0E12 BTU. THE EMISSIONS FROM A DIESEL 699
ENGINE ARE GIVEN IN (0002,3-7). IT IS ASSUMED THAT .04 PC 799
OF THE TOTAL SHIPMENT IS LOST DUE TO WINDAGE (FOOTNOTE 1322). 899
THE AMOUNT RELEASED AS PARTICULATES IS, THEREFORE, 18.9 T. 999

1331

FUEL CONSUMPTION FOR TRANSPORT BY TRUCK IS ESTIMATED TO BE 7700 GAL/1.0E12 BTU EQUIVALENT T HAULED (FOOTNOTE 1330). THUS, THE ENERGY CONSUMPTION IS 1.07E9 BTU (5.825E6 BTU/BBL).

1332

THE LAND USE BY DIESEL FREIGHT TRUCKS IS 1.67E-6 AC/TMI (FOOTNOTE 7026). THUS, THE LAND IMPACT ATTRIBUTED TO THE HAULAGE OF THE COAL BY TRUCK IS 1.84 AC-YR/1.0E12 BTU (FOOTNOTE 1330).

1333

DIESEL FUEL CONSUMPTION BY MIXED TRAIN AMOUNTS TO 9.12E4 GAL/ 1.0E12 BTU EQUIVALENT T HAULED. THUS, THE ENERGY CONSUMPTION IS 1.26E10 BTU (5.825E6 BTU/BBL) (SEE FOOTNOTE 1328).

1334

A BARGE CONSUMES 378 BTU/TMI (FOOTNOTE 7001). THUS, FOR AN AVERAGE HAULAGE DISTANCE OF 300 MI (FOOTNOTE 1329), A BARGE CAPACITY OF 25000 T AND ASSUMING A GROSS TO TARE WEIGHT RATIO OF 4 TO 1, THE ENERGY CONSUMPTION IS 8.94E9 BTU/1.0E12 BTU.

1335

WHEN A CONVEYOR IS USED FOR DISTRIBUTION OF COAL, IT IS GENERALLY USED IN CONJUNCTION WITH ANOTHER MODE OF TRANSPORTATION, E.G., BARGE OR TRAIN. THE HAULAGE DISTANCE IS RELATIVELY SHORT. ONE OF THE LONGER (12 MI) SYSTEMS IS IN OPERATION IN WESTERN KENTUCKY (1045) AND UTILIZES A CABLE DRIVEN CONVEYOR. FOR THE PURPOSES OF THIS ANALYSIS IT IS ASSUMED THAT THE AVERAGE CONVEYOR LENGTH IS 5 MI. HENCE, FOR A RIGHT-OF-WAY OF 30 FT, 18.2 AC OF LAND IS OCCUPIED. THE SYSTEM TRANSPORTS 2 MMT/YR. THEREFORE IN TERMS OF ENERGY, 0.420 AC-YR/1.0E12 BTU OF LAND IS IMPACTED.

1336

ELECTRICAL ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYERS IS 4.06E4 KWH/1.0E12 BTU (FOOTNOTE 1053). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF ELECTRICAL ENERGY CONSUMPTION.

1337

STORAGE OF THE COAL IN A PILE AVERAGING 30 FT IN HEIGHT REQUIRES THE USE OF 0.879 AC-YR/1.0E12 BTU
IT IS ASSUMED THAT UNDERGROUND STORAGE ALSO REQUIRES THE SAME AMOUNT OF LAND.

1338

GENERALLY, SILOS HAVE A DIAMETER OF 70 FT AND ARE ABOUT 150 FT IN HEIGHT. THE STORAGE CAPACITY IS APPROXIMATELY 11000 T (1006). THUS, 5 SILOS ARE REQUIRED FOR STORING 1.0E12 BTU EQUIVALENT T. THE LAND IMPACTED BY THE SILOS IS THEREFORE 0.441 AC-YR/ 1.0E12 BTU.

1339

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYERS FOR STORAGE AMOUNTS TO 1.72E4 KWH/1.0E12 BTU (FOOTNOTES 1058,1059, 1060). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMED.

1340

THE BTU EFFICIENCYFOR THE DENSE MEDIUM BATH WHICH WASHES 56 PC OF FEED IS 95.2 PC, WHILE THE UNWASHED PORTION (44 PC) HAS A 100 PC EFFICIENCY (SEE FOOTNOTE 1316). THUS, THE WEIGHTED AVERAGE EFFICIENCY FOR THE PLANT IS 97.3 PC.

1341

ENERGY CONSUMPTION AT THE PREPARATION PLANT IS 2.42E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION, 1.83E5 KWH ARE ELECTRICAL ENERGY AND 5.36E8 BTU ARE OIL (ASSUMING ALL FUEL PURCHASED TO BE OIL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER CONSUMPTION TO THE FUEL USE. (SEE REF. (1064,12A-16,39)).

1342

ENERGY CONSUMPTION AT A CRUSHING AND SIZING PLANT IS ABOUT 1.81E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION, ELECTRICITY AMOUNTS TO 1.59E5 KWH AND 2.72E8 BTU IS OIL ASSUMING FUEL PURCHASED TO BE OIL AT A COST OF $.20/GAL (1064, 12A-16,39). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMPTION TO THE OIL USAGE.

1343

BY LINEARLY INTERPOLATING THE DATA BETWEEN A 1 AND A 3 MMT/YR AREA STRIPPING OPERATION IN WESTERN KENTUCKY (1041,32,54) THE ENERGY REQUIREMENT FOR A 2 MMT/YR OPERATION IS ESTIMATED. IT IS ASSUMED THAT OILS ARE DIESEL FUEL COSTING $0.20/GAL AND THE COST OF ELECTRICAL POWER TO BE $0.015/KWH. THE TOTAL ENERGY CONSUMPTION FOR THE EXTRACTION OF 1.0E12 BTU EQUIVALENT T IS COMPUTED TO BE 8.00E9 BTU, WHICH IS COMPOSED OF 1.31E9 BTU OF DIESEL FUEL AND 6.54E5 KWH OF ELECTRICAL ENERGY. THE TOTAL IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMPTION ADDED TO THE FUEL USAGE. ON A 1.0E12 BTU IN BASIS THE ENERGY CONSUMPTION IS 6.48E9 BTU.

1344

FUEL CONSUMPTION BY HAULAGE TRUCKS AMOUNTS TO 2920 GAL/1.0E12 BTU. THUS THE ENERGY CONSUMPTION IS 4.05E8 BTU (5.825E6 BTU/BBL).(SEE FOOTNOTE 1312).

1345

THE CONVEYOR SYSTEM CONSUMES 1.03E6 KWH/YR OR ABOUT 24300 KWH/1.0E12 BTU (FOOTNOTE 1049). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT.

1346

A CRUSHER OPERATING AT 275 T/HR AND CRUSHING TO A TOPSIZE OF 1.5 IN. REQUIRES A 140 HP MOTOR (1014,7-14). THUS, 1.79E4 KWH OF ENERGY ARE UTILIZED TO CRUSH 1.0E12 BTU EQUIVALENT T OF COAL. THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT.

1347

THE EXPENSE INCURRED FOR ELECTRICAL POWER IS ESTIMATED TO BE $0.17/T AT $0.01/KWH (1079). THUS, THE ENERGY REQUIREMENT FOR AN UNDERGROUND MINING OPERATION IS 8.15E5 KWH/1.0E12 BTU EQUIVALENT T EXTRACTED (AT 10600 BTU/LB, FOOTNOTE 1300). THE REAL ENERGY CONSUMPTION IS 8.34E9 BTU/1.0E12 BTU (3 TIMES THE BTU EQUIVALENT OF THE ENERGY REQUIREMENT). ON A 1.0E12 BTU IN BASIS THE ENERGY CONSUMPTION IS 4.75E9 BTU.

1348

WINDAGE LOSSES FOR UNIT TRAIN, BARGE, AND TRUCKING AMOUNT TO .04P (FOOTNOTES 1322, 1329, 1330), WHILE FOR MIXED TRAIN LOSSES AMOUNT TO .08P (FOOTNOTE 1328).

		CONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		FUEL	REGION														
		COAL	CENTRAL	WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL 12)													
ROW	MNE-MON	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS PO_4	DISSOLVED SOLIDS NO_3	DISSOLVED SOLIDS OTHER	DISSOLVED SOLIDS TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12}BTU)	PARTIC-ULATES	NO_x
1	EXTRC	EXTRACTION															
2	UNDRG	UNDERGROUND															
3	ROOMP	ROOM & PILLAR		0.00+00 1 1352	4.20+01 4 1353	0000	0000	1.41+01 3 1353	1.41+01 4	2.10+01 2 1353	0000	1.43+01 4	0000	0.00+00 1 0007	0000	0.00+00 1 1014	0.00+00 1 1014
4	SURFC	SURFACE															
5	STRP-	< 10° SLOPE		0.00+00 1 1350	3.98+01 4 1350	0000	0000	1.34+01 3 1350	1.34+01 4	1.97+01 2 1350	0000	1.36+01 4	0000	0.00+00 1 0007	0000	4.97+02 3 1300	1.42+00 3 1300
6	TRNSP	TRANSPORTATION															
7	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0.00+00 2 1300	0000	0.00+00 2	0000	0000	0000	1.90-01 3 1313	5.40-01 3 1313
8	CONVY	CONVEYOR		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1013	0.00+00 1 1013
9	MNRR	MINE RAIL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1043	0.00+00 2 1043
10	PROCS	PROCESSING															
11	PRIMB	PRIMARY BREAKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1080	0000
12	SCLEN	SCOUR CLEANING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1080	0000
13	RSIZE	RAW COAL SIZING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1080	0000
14	DMSEC	DENSE MEDIA (COARSE)		0000	0000	0000	0000	0.00+00 5 0000	0.00+00 5	1.36+02 4 1317	0000	1.36+02 4	0000	0.00+00 1 0007	0000	0000	0000
15	BRKSZ	BREAKING & SIZING		0000	0000	0000	0000	0.00+00 2 1078	0.00+00 2	0.00+00 2 1078	0000	0.00+00 2	0000	0.00+00 1 0007	0000	0.00+00 2 1077	0000
16	STEAM	STEAM COAL PLANT		0.00+00 2 1300	0000	0000	0000	0.00+00 2 1300	0.00+00 2	1.12+00 4 1300	0000	1.12+00 4	0000	0.00+00 1 0007	0000	0.00+00 2 1301	0.00+00 2 1301
17	DISTB	DISTRIBUTION															
18	UNITT	UNIT TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.03-01 4 1322	6.17+00 3 1322
19	MIXT	MIXED TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.69-01 4 1320	2.42+00 3 1320
20	BARGE	RIVER BARGE		0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	2.00-01 4 1320	7.84-01 4 1320
21	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.00-01 4 1330	1.66+00 4 1330
22	CONVY	CONVEYORS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1313	0000
23	STORA	STORAGE															
24	ABRNG	ABOVE GROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000
25	UGRNG	UNDERGROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	0000
26	SILOS	SILO OR BIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
27																	
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1300 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF CENTRAL COAL AND REGIONAL DESCRIPTION.

HITTMAN

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	ROW
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL BTU/10^{12} BTU	PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/10^{12} BTU	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	
																1
																2
0000	0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	6.40-01 3 1354	1.20-02 2 1353	5.97-03 1 1301	6.21+01 1 1301	2.78+01 1 1301	1078	3.79-01 1 1001	6.84+09 3 1351	3
																4
0007	0000	4.97-02 5 1300	1.42+00 5 1300	1.03-01 5 1300	1.42-01 5 1300	8.61-01 5 1300	2.30-00 5 1300	7.60+00 5	5.63-02 5 1354	1.52+01 3 1357	2.75-03 1 1301	1.60+01 3 1301	5.99+00 1 1301	1081	3.19-01 1 1096	6.62+09 4 1355	5
											1.11-03 1 1302	7.74+02 1 1302	3.12+00 1 1302				6
0000	0000	1.90-02 3 1312	3.00-01 3 1312	1.84-07 3 1312	5.00-02 3 1312	2.82-01 3 1312	6.79-07 3 1312	1.03+00 3	0000	6.79-01 3 1356	0000	0000	0000	1081	1.00+00 1 1000	6.83+08 3 1362	7
0000	0000	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0000	0.00+00 2 1012	0000	0000	0000	1082	1.00+00 1 1000	2.00+00 6 1365	8
0000	0000	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0000	0.00+00 2 1042	0000	0000	0000	1083	1.00+00 1 1000	0000	9
											7.76-00 1 1303	1.71-02 5 1303	4.51-01 5 1303				10
0000	0000	0.00+00 2 1080	0000	0000	0000	0000	0.00+00 2	0.00+00 1 1007	0000	0000	0000	0000	0000	1082	1.00+00 1 1007	1.83+06 2 1360	11
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0.00+00 2	3.83+00 6 1316	0000	0000	0000	0000	0000	1083	1.00+00 1 1007	0000	12
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0.00+00 2	0.00+00 1 1007	0000	0000	0000	0000	0000	1083	1.00+00 1 1007	0000	13
0007	0000	0000	0000	0000	0000	0000	0000	7.32-03 3 1317	0000	0000	0000	0000	0000	1083	6.83-01 2 1316	0000	14
0007	0000	0.00+00 2 1077	0000	0000	0000	0000	0000	2.83-03 4 1318	0.00-01 3 1300	1792	0000	0000	0000	1083	1.00+00 1 1000	1.81+00 6 1363	15
0007	0000	0.00+00 3 1361	0.00+00 3 1361	0.00+00 3 1361	0.00+00 3 1361	0.00+00 3 1361	0.00+00 3	4.13-03 3 1362	2.39+01 3 1363	1410	0000	0000	0000	1083	0.73-01 2 1360	2.35+02 4 1364	16
																	17
0000	0000	2.01-01 4 1322	6.17+00 3 1322	3.70+00 3 1322	2.00+00 3 1322	1.90+00 3 1322	8.70-01 3 1322	1.50+01 3	0000	5.06+01 3 1324	6.03-02 3 1325	6.70-01 3 1325	6.13+01 3 1325	1082	1.00+00 3 1340	2.50+10 3 1333	18
0000	0000	1.50+01 4 1320	3.42+00 5 1320	2.00+00 5 1320	2.20+00 5 1320	3.10+00 5 1326	5.02-01 3 1326	5.12+01 5	0000	3.04+01 3 1324	6.03-02 3 1325	6.70-01 3 1325	6.13+01 3 1325	1083	1.00-01 3 1340	7.30-10 5 1333	19
0007	0.00+00 1 0007	2.00+01 4 1320	7.00+01 4 1320	6.50-01 4 1320	5.00-01 4 1320	6.70-01 4 1320	4.04-02 4 1320	2.39+01 4	0000	0000	1.03-01 3 1326	5.21-03 3 1326	3.43-01 5 1326	1083	1.00+00 3 1340	0.00+00 4 1336	20
0000	0000	1.50-01 4 1330	1.00+00 4 1330	1.04-01 4 1330	1.40-01 4 1330	6.00-01 4 1330	2.21-02 4 1330	7.15+01 4	0000	7.00+00 2 1332	3.24-02 5 1327	9.92-01 5 1327	4.54+01 5 1327	1083	1.00+00 3 1340	1.07+00 4 1331	21
0000	0000	0.00+00 1 1012	0000	0000	0000	0000	0000	0.00+00 1	0000	4.29-01 3 1335	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1083	1.00+00 3 1003	4.10+00 4 1336	22
																	23
0007	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.79-01 2 1337	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1083	0.00-01 2 1007	1.70+00 5 1330	24
0007	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.79-01 2 1337	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1083	0.00-01 2 1007	1.70+00 5 1330	25
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.61-01 2 1338	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1083	0.93-01 2 1007	1.70+00 5 1330	26
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TABLE 6. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED CENTRAL REGION OF COAL SUPPLY

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1350

A HYDRATED LIME SYSTEM IS USED TO NEUTRALIZE THE DISCHARGE FROM THE UNDERGROUND MINE. ASSUMING AN ACID LOAD OF 250 PPM THE PLANT WILL HAVE TO PROCESS ABOUT 0.6 MMGAL/DAY (FOOTNOTE 1305, MINE DRAINAGE POLLUTANT LOADS). THUS, THE SOLID WASTE PRODUCTION IS ABOUT 3.0 AC-FT/YR (ESTIMATED FROM DATA IN (1102,233)). ASSUMING A PRECIPITATE DENSITY OF 71 LB/CF (1114, 288) SOLID WASTE PRODUCED AT A RATE OF 4640 T/YR FOR A 2 MM TPY MINE OR 62.4 TON/1.0E12 BTU IN.

THIS IS IN ADDITION TO THE SOLID WASTE PRODUCED DURING THE MINING OPERATION - 1.61 T/1.0E12 BTU (FOOTNOTE 1306).

1351

THE AVERAGE ANNUAL POWER REQUIREMENT IS 1.10E6 KWH/MMGAL/D (FOOTNOTE 1101). THUS, TO OPERATE THE 0.6 MMGAL/D HYDRATED LIME FACILITY 0.66E6 KWH/YR, OR 8.82E3 KWH/1.0E12 BTU IN ARE EXPENDED. THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICITY CONSUMED.

THIS ENERGY IS IN ADDITION TO THE ENERGY REQUIRED FOR THE MINING OPERATION, I.E., 4.75E9 BTU (FOOTNOTE 1347).

1352

IT IS ASSUMED THAT THE FINAL DISCHARGE WILL BE IN COMPLIANCE WITH THE GUIDELINES ESTABLISHED BY EPA (1112). IN LIME TREATMENT, BECAUSE OF THE SOLUBILITY OF CALCIUM SULFATE, THE HARDNESS OF THE WATER WILL INCREASE (1113,24). MOST OF THE METALLIC SALTS WILL PRECIPITATE AS THE PH OF THE SOLUTION IS RAISED. THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	PPM	T/1.0E12 BTU IN
SUSPENDED SOLIDS	30	.210
ACIDITY	0	0.00
ALKALINITY	60	.420
IRON	4	.0280
MN	4	.0280
AL	1	.00701
$CASO_4$	2000	14.0
SUBTOTAL		14.1

THE ALKALINITY CONCENTRATION IS OBTAINED FROM DATA IN REF. (1103), THE MN AND AL FROM SOLUBILITY CURVES, WHILE THE REMAINDER ARE IN COMPLIANCE WITH THE EPA GUIDELINES. THE VOLUME OF THE DISCHARGE IS ABOUT 85 PC OF THE INFLOW VOLUME (1103), I.E., 0.51 MMGAL/DAY. THE FACILITY OPERATES 245 D/YR.

1353

IT IS ASSUMED THAT THE TREATMENT FACILITY REQUIRES A 1.5 MMGAL RAW WATER STORAGE POND AND A 30 MMGAL SETTLING POND. THE LAND IS ASSUMED AVAILABLE. FOR A DEPTH OF 20 FT FOR BOTH PONDS, 4.8 AC OF SURFACE AREA ARE REQUIRED. THE TREATMENT PLANT OCCUPIES ABOUT 3 AC (1114). THUS, THE TOTAL LAND IMPACT IS .184 AC-YR/1.0E12 BTU OUT OR .105 AC-YR/1.0E12 BTU IN.

THIS IS IN ADDITION TO THE 120 AC-YR/1.0E12 BTU IN OF LAND IMPACTED DURING MINING (FOOTNOTE 1304).

1354

A HYDRATED LIME PROCESS IS UTILIZED TO NEUTRALIZE THE ACID DRAINAGE FROM THE AREA STRIPPING OPERATION. ASSUMING AN ACID LOAD OF 500 PPM THE PLANT WILL HAVE TO PROCESS 0.4 MMGAL/DAY (FOOTNOTE 1310, MINE DRAINAGE POLLUTANT LOADS). THE TOTAL IRON CONCENTRATION IS ABOUT 75 PPM. THE SOLID WASTE PRODUCTION FOR

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THE PLANT AMOUNTS TO ABOUT 4.4 AC-FT/YR (1102,233). ASSUMING 799
A PRECIPITATE DENSITY OF 71 LB/CF (1114,288), SOLID WASTE IS 899
GENERATED AT A RATE OF 6800 T/YR, OR 130 T/1.0E12 BTU IN. 999
THIS IS IN ADDITION TO THE 433 T/1.0E12 BTU IN OF SOLID WASTE 1099
PRODUCED DURING STRIPPING (FOOTNOTE 1308). 1199

1355 199

THE ENERGY REQUIREMENT TO OPERATE A 0.4 MMGAL/DAY HYDRATED LIME 299
PLANT IS 0.440E6 KWH/YR, OR 8.33E3 KWH/1.0E12 BTU IN (FOOTNOTE 399
1351). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVA- 499
LENT OF THE ELECTRICAL ENERGY CONSUMED. 599
THE SPOILS ARE STACKED IN PILES ABOUT 80 FT HIGH. ASSUMING 699
GEOMETRICALLY UNIFORM PARALLEL SPOIL PILES RESTING AT AN ANGLE 799
OF REPOSE OF 38 DEGREES, THE PEAK TO PEAK DISTANCE IS ABOUT 899
100 FT. THUS THE ENERGY CONSUMED DURING THE LEVELING OF THE 999
SPOIL BANKS AMOUNTS TO 3920 HP-HR/AC ((1222,67) AND ASSUMING 1099
A 6 PC PERFORMANCE EFFICIENCY), OR 5.56E7 BTU/1.0E12 BTU IN 1199
(FOOTNOTE 1307, LAND TO BE RECLAIMED). 1299
THE ENERGY UTILIZED FOR WASTE WATER TREATMENT AND RECLAMATION 1399
ARE IN ADDITION TO THE ENERGY USED DURING THE MINING OPERATION 1499
- 6.48E9 BTU (FOOTNOTE 1343). 1599

1356 199

IT IS ASSUMED THAT THE FINAL DISCHARGE WILL BE IN COMPLIANCE WITH 299
THE GUIDELINES ESTABLISHED BY EPA (1112). THE VOLUME OF DIS- 399
CHARGE IS ABOUT 85 PC OF THE INFLOW VOLUME (1103), I.E., 499
0.340 MMGAL/DAY. THE EFFLUENT BREAKDOWN IS AS FOLLOWS (FOOT- 599
NOTE 1352). THE FACILITY OPERATES 245 D/YR. 699

	PPM	T/1.0E12 BTU IN	
			799
SUSPENDED SOLIDS	30	.198	899
ACIDITY	0	0.000	999
ALKALINITY	60	.398	1099
			1199
IRON	4	.0266	1299
MN	4	.0266	1399
AL	1	.00663	1499
$CASO_4$	2000	13.3	1599
SUBTOTAL		13.4	1699

1357 199

FOR AREA STRIPPING (SLOPE LESS THAN 15 DEGREES) 5.57 AC OF LAND 299
ARE OVERTURNED PER 1.0E12 BTU IN (FOOTNOTE 1307). 399
499
IN TIME AVERAGING THE LAND IMPACT THE EFFECTS OF RECLAMATION 599
MUST BE CONSIDERED. RECLAMATION IN THIS CASE REQUIRES THE 699
RESTORATION OF THE LAND TO THE ORIGINAL CONTOUR (OR AS CLOSE 799
TO THE ORIGINAL CONTOUR AS POSSIBLE), AND STABILIZING THE 899
SURFACE AGAINST EROSION. MINIMIZING EROSION INVOLVES BENEFI- 999
CIAL GRADING (TERRACING, GOUGING, ETC.) AND ESTABLISHING AN 1099
HERBACEOUS COVER. IN APPALACHIA ABOUT 3 GROWING SEASONS ARE 1199
REQUIRED TO ESTABLISH A 95 PC COVER OF GRASS AND LEGUMES 1299
(1101). IT IS ASSUMED THIS ALSO APPLIES IN THIS REGION, SINCE 1399
ADEQUATE MOISTURE AND TOPSOIL ARE GENERALLY AVAILABLE. 1499
USING THE 3 YR CRITERION THE TIME AVERAGED LAND IMPACT IS 1599
15.7 AC-YR/1.0E12 BTU IN. THE LAND IMPACT DUE TO THE WASTE 1699
PILE IS ASSUMED TO BE NIL, WHICH IMPLIES INSTANTANEOUS 1799
RECLAMATION. 1899
IT IS ASSUMED THAT THE TREATMENT PLANT REQUIRES A 1 MMGAL RAW 1999
WATER STORAGE POND AND A 45 MMGAL SETTLING POND. THE LAND IS 2099
ASSUMED AVAILABLE. FOR AN AVERAGE DEPTH OF 20 FT FOR BOTH 2199
PONDS, ABOUT 7.0 AC OF SURFACE AREA ARE REQUIRED. THE TREAT- 2299
MENT PLANT OCCUPIES APPROXIMATELY 3 AC (1114). THUS, THE LAND 2399
IMPACT IS 0.191 AC-YR/1.0E12 BTU IN. 2499

1358 199

TO CONTROL SILTATION, THE RUNOFF FROM THE HAUL ROADS ARE DIVERTED 299
TO SETTLING PONDS PLACED ALONG THE ROADWAY (1100). IT IS 399
ASSUMED THAT ALL THE SEDIMENT IS REMOVED. 499

1359 199

IT IS ASSUMED THAT A SETTLING POND IS REQUIRED FOR EACH MILE OF 299
ROAD AND THAT EACH POND USES AN ACRE OF LAND. THUS, 4 AC ARE 399
UTILIZED FOR THE SETTLING POND (THE HAUL ROAD IS 3.8 MI LONG, 499
FOOTNOTE 1312). THE LAND IMPACT IS 0.0945 AC-YR/1.0E12 BTU. 599
THIS IS IN ADDITION TO THE LAND IMPACTED BY THE ROAD - 0.584 699
AC-YR/1.0E12 BTU (FOOTNOTE 1311). 799

1360 199

SEEPAGE FROM THE REFUSE PILE IS ASSUMED TO BE COMPLETELY 299
ELIMINATED BY THE SOIL COVER ESTABLISHED IN RECLAIMING THE 399
REFUSE PILE. RUNOFF FROM THE REFUSE PILE, HOWEVER, CONTINUES 499
BECAUSE OF THE 3 YEAR TIME LAG ASSOCIATED WITH ESTABLISHMENT 599
OF AN HERBACEOUS COVER (FOOTNOTE 1103). BASED ON 2.54 TON 699
SUSPENDED SOLIDS/ACRE-YR-IN RUNOFF AND ON 10 IN RUNOFF AND 799
.149 AC-YR/1.0E12 BTU (FOOTNOTE 1363), 3.78 TON SUSPENDED 899
SOLIDS/1.0E12 BTU ARE GENERATED IN RUNOFF FROM THE RECLAIMED 999
REFUSE PILE. SUSPENDED SOLIDS GENERATED IN THE PREP PLANT ARE 1099
ELIMINATED BY THE USE OF A SETTLING POND. 1199

1361 199

EMISSIONS ASSOCIATED WITH THE BURNING COAL REFUSE PILE (FOOTNOTE 299
1315) ARE COMPLETELY ELIMINATED BY RECLAMATION OF THE REFUSE 399
PILE. BAGHOUSES FOR CONTROL OF FUGITIVE DUST EMISSIONS ARE 499
USED IN THE CONTROLLED UTILITY PREP PLANT IN ORDER TO COMPLY 599
WITH THE 10P OPACITY LIMIT FOR VISIBLE EMISSIONS FROM NEW 699
PREP PLANTS (1121). 799

1362 199

IT HAS NOT BEEN POSSIBLE TO QUANTIFY FUGITIVE DUST EMISSIONS FROM 299
COAL PREP PLANTS. THUS IT IS NOT POSSIBLE TO QUANTIFY THE 399
INCREMENTAL SOLID WASTE GENERATED BY THE USE OF BAGHOUSES TO 499
CONTROL THESE EMISSIONS. THEREFORE, THE SOLID WASTE GENERATED 599
IN THE CONTROLLED UTILITY COAL PREP PLANT IS THE SAME AS GIVEN 699
IN FOOTNOTE 1318, NAMELY 4130 TON/1.0E12 BTU IN. 799

1363 199

BASED ON A SOLID WASTE PRODUCTION OF 4130 TON/1.0E12 BTU (FOOTNOTE 299
1362), A COMPACTED REFUSE DENSITY OF .06 TON/CF, AND A 30 FT 399
HIGH REFUSE PILE, .053 ACRES OF LAND/1.0E12 BTU IS IMPACTED. 499
BASED ON A 3 YEAR TIME LAG TO ESTABLISH AN HERBACEOUS COVER 599
AND A 25 YR PLANT OPERATING LIFETIME, 2.82 TIMES THE YEARLY 699
LAND IMPACT REPRESENTS THE TIME AVERAGED LAND IMPACT (FOOTNOTE 799
1103). THUS .149 ACRE-YR/1.0E12 BTU IS THE TIME AVERAGED LAND 899
IMPACT. THE LAND REQUIREMENT FOR THE UTILITY COAL PREP PLANT 999
IS 2.24 ACRE-YR/1.0E12 BTU (FOOTNOTE 1319) SO THAT THE TOTAL 1099
LAND REQUIREMENT IS 2.39 ACRE-YR/1.0E12 BTU. 1199

1364 199

THE TOTAL POWER REQUIREMENT FOR THE 7 BAGHOUSES IN A 500 TON/HR 299
PREP PLANT IS 175 HP (1080,73) OR 4.55E05 KWH/YR (BASED ON 399
3480 HR/YR OPERATION). CONVERTING THIS BY 10200 BTU/KWH AND 499
SIZING THE RESULT FOR A 1.0E12 BTU/YR PREP PLANT GIVES AN 599
ENERGY REQUIREMENT OF 1.26E08 BTU/1.0E12 BTU. NO INFORMATION 699
WAS AVAILABLE ON ENERGY REQUIREMENTS FOR REFUSE RECLAMATION. 799
THE ENERGY REQUIRED FOR THE CLOSED CIRCUIT SETTLING POND IS 899
BASED ON .0457 $/TON SUSPENDED SOLIDS (FOOTNOTE 1126), 156 T 999
OF SOLIDS (FOOTNOTE 1321), AND $.01/KWH TO GIVE 7.13E02 KWH/ 1099
1.0E12 BTU OR 7.26E06 BTU/1.0E12 BTU (CONVERTING AT 10200 BTU 1199
/KWH). THE SUM TOTAL INCREMENTAL ENERGY DEMAND ASSOCIATED WITH 1299
CONTROLS ON A 1.0E12 BTU/YR UTILITY COAL PREP PLANT IS THUS 1399
1.33E08 BTU/1.0E12 BTU. 1499

		UNCONTROLLED	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		FUEL: COAL / REGION: NORTHERN APPALACHIA	WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL. 12)													
ROW	MNE-MON	ACTIVITY PROCESS	ACIDS	BASES	DISSOLVED SOLIDS: PO_4	DISSOLVED SOLIDS: NO_3	DISSOLVED SOLIDS: OTHER	DISSOLVED SOLIDS: TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12}BTU	PARTIC-ULATES	NO_x
1	EXTRC	EXTRACTION														
2	UNDER	UNDERGROUND														
3	ROOM	ROOM & PILLAR	6.77+01 3 1404	0999	0999	0999	4.38+02 4 1404	4.38+02 4	2.81+02 4 1404	0999	4.38+02 4	0999	0.00+00 1 0997	0999	0.00+00 1 1016	0.00+00 1 1016
4	LONGW	LONGWALL	1.01+02 3 1404	0999	0999	0999	6.54+02 4 1404	6.54+02 4	4.19+02 4 1404	0999	6.54+02 4	0999	0.00+00 1 0997	0999	0.00+00 1 1016	0.00+00 1 1016
5	SURFC	SURFACE														
6	STRP-	<15° SLOPE	6.80+00 3 1407	0999	0999	0999	4.55+01 4 1407	4.55+01 4	6.80+00 3 1407	0999	5.24+01 4	0999	0.00+00 1 0997	0999	6.48+02 5 1408	1.27+00 5 1408
7	STRP+	>15° SLOPE	6.80+00 3 1407	0999	0999	0999	4.50+01 4 1407	4.50+01 4	3.65+03 4 1407	0999	2.70+03 4	0999	0.00+00 1 0997	0999	7.02-02 5 1415	2.00+00 5 1415
8	TRNSP	TRANSPORTATION														
9	TRUCK	TRUCKING	0999	0999	0999	0999	0999	0999	3.46+01 4 1419	0999	3.46+01 4	0999	0999	0999	3.29-02 3 1417	9.16-01 3 1417
10	CONVY	CONVEYOR	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 1 1012	1.00+00 1 1012
11	MINRL	MINE RAIL	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 2 1042	0.00+00 2 1042
12	PROCS	PROCESSING														
13	BREAK	PRIMARY BREAKING	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 2 1009	0999
14	SCLEN	SCREEN CLEANING	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 2 1009	0999
15	RNBIE	RAW COAL SIZING	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 2 1009	0999
16	DMRDC	DENSE MEDIA (COARSE)	0999	0999	0999	0999	0999	0999	4.24+01 4 1423	0999	4.24+01 5	0999	0.00+00 1 0997	0999	0999	0999
17	BRKSI	BREAKING AND SIZING	0999	0999	0999	0999	0.00+00 1 1078	0.00+00 1	0.00+00 1 1078	0999	0.00+00 1	0999	0999	0999	0.00+00 2 1077	0999
18	STEAM	STEAM COAL	3.18+01 5 1431	0999	0999	0999	5.02+01 5 1431	5.02+01 5	6.45+01 5 1431	0999	1.44+02 5	0999	0.00+00 1 0997	0999	2.51+00 5 1430	1.25+00 5 1430
19	DISTB	DISTRIBUTION														
20	UNITT	UNIT TRAIN	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	1.64-01 4 1432	4.28+00 3 1432
21	MIXT	MIXED TRAIN	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	5.50+01 5 1432	3.60+00 5 1432
22	BARGE	RIVER BARGE	0999	0999	0999	0999	0999	0999	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1.97+01 4 1432	1.80+00 4 1432
23	TRUCK	TRUCKING	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	1.70+01 4 1441	1.28+00 4 1441
24	CONVY	CONVEYORS	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 1 1017	0999
25	STORA	STORAGE														
26	ABOVE	ABOVE GROUND	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 1 0997	0999	0999	0999
27	UGRNE	UNDER GROUND	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0.00+00 1 0997	0999	0999	0999
28	SILOS	SILOS	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999	0999
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1400 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF NORTHERN APPALACHIAN COAL AND REGIONAL DESCRIPTION.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS / 10^{12} BTU	LAND (ACRE-YR / 10^{12} BTU)	DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	ROW
																1
										0.00+00 1 1450	5.27-01 1 1450	1.00+01 1 1450				2
0000 0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	1.45+00 3 1401	1.20+02 2 1402	0000	0000	0000	1078	5.70-01 1 1001	4.21+09 4 1411	3
0000 0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	2.16+00 3 1401	2.85+02 2 1403	0000	0000	0000	1078	9.50-01 1 1000	5.64+09 4 1411	4
										6.93-01 1 1450	1.24+01 1 1450	7.49+00 1 1450				5
0000 0000	4.48-02 5 1409	1.27+00 5 1409	9.30-01 5 1409	1.27-01 5 1409	7.75+01 5 1409	2.07+02 5 1409	2.33-00 5	3.52+02 2 1409	7.15+01 2 1409	0000	0000	0000	1081	8.10-01 1 1004	5.82+00 5 1409	6
0000 0000	7.02-02 5 1412	2.00+00 5 1412	1.46-01 5 1412	2.00-01 5 1412	1.22+00 5 1412	3.24-02 5 1412	3.67+00 5	5.68+00 2 1412	1.58+00 2 1412	0000	0000	0000	1081	9.50-01 1 1003	1.00+10 5 1410	7
										5.47-01 2 1451	2.47-01 2 1451	8.82+00 2 1451				8
0000 0000	3.29-02 3 1417	9.36-01 3 1417	6.83-02 3 1417	9.38-02 3 1417	5.59-01 3 1417	1.52-02 3 1417	1.72+00 3	0000	0.90+01 2 1418	0000	0000	0000	1082	1.00+00 1 1008	7.02+08 3 1418	9
0000 0000	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1	0000	0.00+00 2 1012	0000	0000	0000	1083	1.00+00 1 1008	2.23+08 4 1418	10
0000 0000	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2	0000	0.00+00 2 1042	0000	0000	0000	1083	1.00+00 1 1008	0000	11
										7.39-04 1 1453	4.67-02 1 1453	1.40+00 1 1453				12
0000 0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1082	1.00+00 1 1007	1.65+08 2 1419	13
0000 0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	2.24+00 3 1421	0000	0000	0000	0000	1082	1.00+00 1 1007	0000	14
0000 0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1082	1.00+00 1 1007	0000	15
0000 0000	0000	0000	0000	0000	0000	0000	0000	6.78-03 2 1422	0000	0000	0000	0000	1083	8.50-01 2 1433	0000	16
0000 0000	0.00+00 2 1077	0000	0000	0000	0000	0000	0000	2.54-00 3 1421	7.61-01 2 1423	0000	0000	0000	1081	1.00+00 1 1009	1.72+08 4 1424	17
0000 0000	2.11+00 5 1430	1.25+00 5 1430	3.70+00 5 1430	1.25+01 5 1430	7.52+00 5 1430	0000	1.62+01 5	3.07+03 3 1425	3.18+00 3 1427	0000	0000	0000	1082	9.64-01 2 1428	2.17+08 4 1429	18
																19
0000 0000	1.64+01 4 1432	4.28+00 3 1432	3.11+00 3 1432	2.85+00 3 1432	4.00+00 3 1432	4.27-01 3 1432	3.59+01 3	0000	2.76+01 3 1436	8.46-02 3 1435	8.56-01 3 1435	7.98+01 3 1435	1082	1.00+00 3 1001	1.38+10 3 1435	20
0000 0000	5.50+01 5 1438	3.40+00 5 1438	2.84+00 5 1438	2.27+00 5 1438	3.17+00 5 1438	4.88-01 5 1438	4.[illegible]+01 5	0000	2.76+01 5 1434	8.46-02 3 1435	8.56-01 3 1435	7.98+01 3 1435	1082	9.00-01 3 1001	1.28+10 5 1439	21
0000 0000	1.97+01 4 1438	1.00+00 4 1438	2.34+00 4 1438	1.22+00 4 1438	1.83+00 4 1438	9.50-02 4 1438	3.84+01 4	0000	1.93+03 3 1440	3.21-03 5 1440	2.43-01 5 1440	1.00+00 3 1001	1082	1.00+00 3 1001	2.13+10 4 1438	22
0000 0000	1.70+01 4 1441	1.28+00 4 1441	8.32-02 4 1441	1.26-01 4 1441	7.76-01 4 1441	2.07-02 4 1441	1.03+01 4	0000	1.87+00 4 1442	3.24-02 5 1444	6.92-01 5 1444	4.34+01 5 1444	1082	1.00+00 3 1001	8.58+08 4 1442	23
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TABLE 7. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED NORTHERN APPALACHIA REGION OF COAL SUPPLY

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FOOTNOTES FOR TABLE 7

1400

THE REGION OF NORTHERN APPALACHIA INCLUDES CENTRAL AND WESTERN PENNSYLVANIA, NORTHERN W. VIRGINIA AND OHIO. THE AVERAGE CALORIC CONTENT OF COAL DELIVERED TO ELECTRIC UTILITIES IN THIS REGION DURING THE 3RD AND 4TH QUARTERS OF 1972 WAS 11800 BTU/LB (1212 AND 1213). THE AVERAGE ASH AND SULFUR CONTENT OF THE COAL IN THIS REGION, INCLUDING MARYLAND, IS 14.7 AND 3.07 PC, RESPECTIVELY (1053,9).(THE AVERAGE SULFUR CONTENT OF COAL DELIVERED TO ELECTRIC UTILITIES DURING THE 3RD QUARTER OF 1972 WAS 2.31 PC (1212).)

FOR THE COAL IN THIS REGION,1.0E12 BTU IS EQUIVALENT TO 42400 T OF COAL. ALL COMPUTATIONS ARE BASED ON 1.0E12 BTU IN. THE DENSITY OF THE COAL IS ABOUT 85 LB/CF (1050).

1401

SOLID WASTE PRODUCTION FROM UNDERGROUND MINES IS IN GENERAL RELATED TO THE OPENING OF THE MINE (SHAFT SINKING FOR SHAFT AND SLOPE MINES). ASSUMING AN AVERAGE MINE DEPTH OF 600 FT AND AN ADIT OF 100 SF, 3000 T OF EARTH ARE REMOVED TO SINK THE SHAFT.

SIZABLE UNDERGROUND MINES HAVE AN AVERAGE PRODUCTIVE LIFE OF ABOUT 25 YRS PRODUCING 2 MMT/YR (1018). HENCE, SOLID WASTE IS PRODUCED AT A RATE OF 60 T/MMT OF COAL MINED, OR 1.45 T/1.0E12 BTU IN FOR ROOM AND PILLAR MINING AND 2.16 T/ 1.0E12 BTU IN FOR LONGWALL MINING.

1402

THE AVERAGE SEAM THICKNESS OF COAL MINED UNDERGROUND IN THIS REGION IN 1965 WAS 5.1 FT (1017). ASSUMING THIS VALUE STILL APPLIES, 4.49 AC OF LAND ARE UNDERMINED PER 1.0E12 BTU EQUIVALENT TON IN.

OF THE ACREAGE UNDERMINED APPROXIMATELY 25P WILL SUBSIDE (1019). THIS SUBSIDENCE RATE IS ACTUALLY FOR ALL UNDERGROUND COAL MINES, BUT SINCE THE ROOM & PILLAR TECHNIQUE HAS BEEN PREDOMINANT IN THE U.S., IT IS ASSUMED THAT THIS FIGURE CHARACTERIZES THE SUBSIDENCE FOR ROOM & PILLAR MINING. EVENTUALLY ALL OF THE AREA UNDERMINED MAY SUBSIDE, BUT THE TIME SCALE IS IN EXCESS OF A CENTURY. THE 25P SUBSIDENCE RATE IS DERIVED FROM HISTORICAL OBSERVATIONS.

SUBSIDENCE AFFECTS A SURFACE AREA GREATER THAN THE AREA UNDERMINED. THE WIDTH ON THE PERIMETER THAT IS AFFECTED BY SUBSIDENCE IS DETERMINED FROM

$$R=H \tan X$$

WHERE, R=WIDTH OF THE PERIMETER AREA AFFECTED, H=DEPTH OF MINE, AND X=ANGLE OF DRAW (ANGLE BETWEEN A VERTICAL LINE, AND A LINE CONNECTING THE FACE AND THE LIMIT OF SUBSIDENCE). THE ANGLE OF DRAW HAS BEEN CONSISTENTLY OBSERVED IN EUROPEAN COAL FIELDS TO FALL BETWEEN 35-39 DEGREES (1027,232,233). THUS,FOR AN ANGLE OF DRAW OF 37 DEGREES AND A MINE DEPTH OF 600 FT, THE WIDTH OF THE AFFECTED PERIMETER AREA IS 452 FT.

OF THE UNDERMINED AREA 1.12 AC SUBSIDES. ASSUMING A SQUARE AREA, THE SIDES ARE 221 FT IN LENGTH. HENCE, AN ADDITIONAL 9.17 AC ARE AFFECTED. THE TOTAL AREA AFFECTED BY SUBSIDENCE ENCOMPASSES 10.3 AC.

TIME AVERAGING THIS VARIABLE LAND USAGE OVER 25 YRS,(FOOTNOTE 1401) THE LAND IMPACT IS 129 AC-YR/1.0E12 BTU IN.

IN A PILE 30 FT IN HEIGHT, 4.59 E-2 AC OF LAND IS OCCUPIED BY THE REFUSE PILE (FOOTNOTE 1401, SOLID WASTE PRODUCTION). FOR

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AN ANNUAL PRODUCTION OF 2 MMT (FOOTNOTE 1041), THE LAND IMPACT IS 5.53E-4 AC-YR/1.0E12 BTU IN.

1403

THE AVERAGE SEAM THICKNESS IS 5.1 FT (FOOTNOTE 1402). THUS, 4.49 AC ARE UNDERMINED FOR EACH 1.0E12 BTU IN. SINCE IN LONGWALL MINING THE ROOF IS COLLAPSED AS MINING PROGRESSES, IT IS ASSUMED THAT ALL OF THE SURFACE AREA UNDERMINED WILL SUBSIDE. THE WIDTH OF THE AREA OF INFLUENCE IS 452 FT (FOOTNOTE 1402) AND, ASSUMING A SQUARE AREA, THE LENGTH OF THE SIDES OF THE UNDERMINED ACREAGE IS 442 FT. HENCE, AN ADDITIONAL 18.3 AC ARE AFFECTED BY SUBSIDENCE.
THE TIME AVERAGED (OVER 25 YRS, FOOTNOTE 1401) VALUE OF THE LAND IMPACTED BY SUBSIDENCE IS 285 AC-YR/1.0E12 BTU IN.
THE LAND UTILIZED FOR STORAGE OF THE REFUSE IS 8.25E-4 AC-YR/1.0E12 BTU IN (FOOTNOTE 1402).

1404

IT IS ASSUMED THAT THE DRAINAGE FROM UNDERGROUND MINES IS THE SAME REGARDLESS OF THE METHOD UTILIZED. THIS IS NOT STRICTLY TRUE. SINCE THE RATE OF SUBSIDENCE FOR LONGWALL MINING IS GREATER, THE AMOUNT OF SEEPAGE (THROUGH FAULTS) INTO THE MINE WILL TEND TO BE LARGER THEREBY LEADING TO INCREASED DRAINAGE. BUT IT IS ALSO TRUE THAT THE DRAINAGE BETWEEN MINES, IRRESPECTIVE OF THE MINING TECHNIQUE EMPLOYED, WILL VARY TO A DEGREE THAT MAY EVEN BE GREATER.
THE ACID DRAINAGE FROM ACTIVE DEEP MINES IN NORTHERN APPALACHIA OCCURS AT A RATE OF 905 T OF ACIDITY/DAY, OR 0.0028 T/T OF COAL MINED. (THE ACIDITY IS COMPUTED FROM DATA ON SUB-AREAS 3-13 AND 16 IN REF. (1039,5,8,9) ASSUMING THE CONTRIBUTION FROM THE DIFFERENT SOURCES ARE IN THE SAME PROPORTION AS FOR ALL OF APPALACHIA. THE PRODUCTION FIGURES ARE OBTAINED FROM REF. (0001).) THE SULFATE LOADING IS ABOUT TWICE AS MUCH AS THE ACID LOADING (1039).
THE CHEMICAL COMPOSITION OF THE DRAINAGE FROM THE ACTIVE MINES IS ESTIMATED FROM DATA ON THE MONONGAHELA RIVER BASIN (1039, 133/139). THE DATA FROM 10 GAGING STATIONS WERE USED IN THE ESTIMATION AND THE COAL PRODUCTION FIGURES WERE OBTAINED FROM REF.(0001). IN DETERMINING THE HARDNESS,A CONCENTRATION OF 100 MG/L WAS ASSUMED TO OCCUR NATURALLY, WHILE THE METALLIC CONSTITUENTS ARE ASSUMED TO ORIGINATE FROM THE MINES. THE RELATIVE CONTRIBUTION FROM THE DIFFERENT SOURCES WAS ASSUMED TO BE THE SAME AS FOR ALL OF APPALACHIA. THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	ROOM & PILLAR T/1.0E12 BTU IN	LONGWALL T/1.0E12 BTU IN
HARDNESS	295.0	440.0
FE	5.2	7.7
MN	2.2	3.3
AL	0.65	0.97
SO_4	135.0	202.0
TOTAL	438.1	654.0
ACIDITY	67.7	101.0

THE SEDIMENT YIELD FROM THE SOLID WASTE PILE OCCURS AT A RATE OF 2.54 T/AC-YR-IN OF RUNOFF (COMPUTED FROM DATE IN REF. 1020). THE RUNOFF IN THIS REGION AVERAGES ABOUT 20 IN/YR. THUS, THE SEDIMENT YIELD AMOUNTS TO 2.81E-2 T/1.0E12 BTU IN FOR ROOM AND PILLAR MINES (FOOTNOTE 1402, LAND USE BY REFUSE PILE) AND 4.19E-2T/1.0E12 BTU IN FOR LONGWALL MINES (FOOTNOTE 1403, LAND USE BY REFUSE PILE).

1405

THE AVERAGE DEPTH OF OVERBURDEN OF COAL MINED IN 1965 WAS 47 FT (1017). IN AREA SURFACE MINING ALL OF THE OVERBURDEN, EXCEPT THAT WHICH IS REMOVED DURING THE BOX CUT, IS DEPOSITED IN SPOIL BANKS IN THE EXCAVATED AREA. HENCE, THE SOLID WASTE IS PRODUCED ONLY DURING THE INITIAL EXCAVATION. THE DENSITY OF THE OVERBURDEN IS ABOUT 0.05 T/CF. ASSUMING THAT ON THE AVERAGE 5 AC (PIT SIZE OF ROUGHLY 100 FT BY 2000 FT, (1007)) ARE EXCAVATED FOR THE BOX CUT AND 50 MMT OF COAL ARE CONSEQUENTLY EXTRACTED, SOLID WASTE PRODUCTION OCCURS AT A RATE OF 0.0103 T/T OF COAL, OR 352 T/1.0E12 BTU IN.

THE PRODUCTIVE LIFE OF SIZABLE AREA STRIP MINES IS ABOUT 25 YRS WITH AN AVERAGE OF 2 MMT/YR (1018).

1406

THE AVERAGE SEAM THICKNESS FOR SURFACE MINES IN THIS REGION IS 3.9 FT (1017).

IT IS ASSUMED THAT SURFACE MINING ON SLOPES LESS THAN 15 DEGREES IS DONE BY AREA STRIPPING, WHILE ON STEEPER SLOPES CONTOUR STRIPPING IS EMPLOYED.

FOR A COAL DENSITY OF 85 LB/CF, 5.87 AC OF LAND IS OVERTURNED PER 1.0E12 BTU EQUIVALENT TON IN. THUS, THE TIME AVERAGED (OVER 25 YRS, FOOTNOTE 1405) LAND IMPACT IS 73.4 AC-YR/1.0E12 BTU IN.

IN A PILE 30 FT IN HEIGHT, THE SOLID WASTES PILE OCCUPIES 0.135 AC-YR/1.0E12 BTU IN (FOOTNOTE 1405).

1407

THE ACID DRAINAGE FROM ACTIVE SURFACE MINES IN NORTHERN APPALACHIA OCCURS AT A RATE OF 47 T OF ACIDITY/DAY OR 0.0002 T/T OF COAL MINED (1039,5,8,9) (SEE ALSO FOOTNOTE 1404). THE SULFATE LOADING IS ABOUT TWICE THE ACID LOADING (1039). THE CHEMICAL COMPOSITION OF THE DRAINAGE WAS DETERMINED FROM DATA ON THE MONONGAHELA RIVER BASIN (FOOTNOTE 1404). THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	STRIP T/1.0E12 BTU IN	CONTOUR T/1.0E12 BTU IN
HARDNESS	30.9	30.6
FE	0.5	0.5
MN	0.2	0.2
AL	0.07	0.07
SO_4	13.8	13.6
TOTAL	45.5	45.0
ACIDITY	6.9	6.8

THE SEDIMENT IS YIELDED AT A RATE OF 2.54 T/AC-YR-IN. OF RUNOFF. THE AVERAGE RUNOFF FOR THIS REGION IS ABOUT 20 IN. FOR AREA STRIPPING, THE SEDIMENT YIELD IS 6.86 T/1.0E12 BTU IN (FOOTNOTE 1406, LAND USE BY SOLID WASTE PILE) AND FOR CONTOUR STRIPPING THE SEDIMENT YIELD IS 2650 T/1.0E12 BTU IN (FOOTNOTE 1413, LAND USE SPOIL BANK).

1408

BY LINEARLY INTERPOLATING THE DATA BETWEEN A 1 AND A 2 MMT/YR AREA STRIPPING OPERATION IN WESTERN KENTUCKY (1041,32,54), THE POWER CONSUMPTION FOR A 2 MMT/YR OPERATION IS DETERMINED. IT IS ASSUMED THAT THE OILS ARE DIESEL FUELS COSTING $0.20/GAL AND THE COST OF ELECTRICAL POWER TO BE $0.015/KWH. THE TOTAL ENERGY CONSUMPTION FOR THE EXTRACTION OF 1.0E12 BTU EQUIVALENT T IS COMPUTED TO BE 7.18E9 BTU, WHICH IS COMPOSED OF 1.18E9 BTU OF DIESEL FUEL AND 5.87E5 KWH OF ELECTRICAL POWER. IN OBTAINING THE TOTAL, 3 TIMES THE ELECTRICAL POWER USAGE IS ADDED TO THE FUEL CONSUMPTION. ON A 1.0E12 BTU IN BASIS THE ENERGY CONSUMPTION IS 5.82E9 BTU.

1409

THE DIESEL FUEL CONSUMPTION FOR AN AREA STRIPPING OPERATION IS ESTIMATED TO BE 6890 GAL/1.0E12 BTU IN (FOOTNOTE 1408). THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7) ASSUMING THE CHARACTERISTICS OF A DIESEL TRUCK ENGINE. (HEAT CONTENT OF DIESEL FUEL IS 5.825E6 BTU/BBL) SINCE ADEQUATE MOISTURE IS AVAILABLE IN THIS AREA, FUGITIVE DUST IS NOT EXPECTED TO BE A SERIOUS PROBLEM.

1410

BY LINEARLY INTERPOLATING THE DATA IN REF. (1041,12,23), AND ASSUMING THE OILS TO BE DIESEL FUELS COSTING $0.20/GAL AND THE COST OF POWER TO BE $0.015/KWH THE TOTAL ENERGY CONSUMPTION FOR A 2 MMT/YR CONTOUR STRIPPING OPERATION IS ABOUT 1.36E10 BTU FOR EVERY 1.0E12 BTU EQUIVALENT T EXTRACTED. THE TOTAL IS COMPOSED OF 1.87E9 BTU OF FUEL AND 1.17E6 KWH OF ELECTRICAL POWER. THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER USAGE TO THE FUEL CONSUMPTION. ON A 1.0E12 BTU IN BASIS THE ENERGY CONSUMPTION IS 1.09E10 BTU.

1411

THE EXPENSE INCURRED FOR ELECTRICAL POWER IS ESTIMATED TO BE $0.17/T AT $0.01/KWH (1079). THUS, THE ENERGY REQUIREMENT FOR AN UNDERGROUND MINING OPERATION IS 7.21E5 KWH/1.0E12 BTU EQUIVALENT T EXTRACTED (AT 11800 BTU/LB, FOOTNOTE 1400). THE REAL ENERGY CONSUMPTION IS 7.38E9 BTU/1.0E12 BTU (3 TIMES THE BTU EQUIVALENT OF THE KWH REQUIREMENT).
THE ENERGY CONSUMPTION FOR A LONGWALL MINING OPERATION IS ABOUT 10 PC LESS THAN THE ENERGY USED IN A ROOM AND PILLAR MINE (1079). THUS, FOR EVERY 1.0E12 BTU EQUIVALENT T OF COAL EXTRACTED, 6.49E5KWH OR 6.64E9 BTU OF ENERGY ARE CONSUMED. THE CONDITIONS UNDER WHICH THE ENERGY CONSUMPTION FIGURE WAS DEVELOPED DO NOT EXACTLY COINCIDE WITH THE CONDITIONS UNDER WHICH THE ENVIRONMENTAL IMPACTS WERE DETERMINED (FOOTNOTE 1826). ON A 1.0E12 BTU IN BASIS, THE ENERGY CONSUMPTION FOR ROOM AND PILLAR MINES IS 4.21E9 BTU AND FOR LONGWALL MINING IT IS 5.64E9 BTU.

1412

THE DIESEL FUEL CONSUMPTION FOR A CONTOUR STRIPPING OPERATION IS ESTIMATED TO BE 10800 GAL/1.0E12 BTU IN (FOOTNOTE 1410 AND 5.825E6 BTU/BBL OF DIESEL FUEL). THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7) ASSUMING THE CHARACTERISTICS OF A DIESEL TRUCK ENGINE.
SINCE ADEQUATE MOISTURE IS AVAILABLE IN THIS REGION, FUGITIVE DUST IS NOT EXPECTED TO BE A SERIOUS PROBLEM.

1413

FOR A COAL SEAM THICKNESS OF 3.9 FT (1017) AND A COAL DENSITY OF 85 LB/CF, 5.87 AC OF LAND IS OVERTURNED PER 1.0E12 BTU EQUIVALENT TONS IN.
ON SLOPES GREATER THAN 15 DEGREES, TECHNIQUES OF CONTOUR STRIPPING ARE EMPLOYED. IT IS ASSUMED THAT THE CONVENTIONAL CONTOUR MINING IS USED. EXCEPT FOR THE MATERIAL USED TO BACKFILL THE BENCH, ALL OF THE OVERBURDEN IS DEPOSITED ON THE OUTSLOPE AND ASSUMED TO REST AT THE ANGLE OF REPOSE (ABOUT 37 DEGREES). IT IS ALSO ASSUMED THAT A 15 FT RIM OF BLOSSOM COAL IS LEFT IN PLACE. THE MEAN SLOPE ANGLE AND THE BENCH WIDTH ARE ASSUMED TO BE 20 DEGREES (1028, 51) AND 150 FT RESPECTIVELY. (THE 20 DEGREE SLOPE ANGLE IS THE AVERAGE FOR SLOPES GREATER THAN 15 DEGREES IN NORTHERN APPALACHIA). HENCE, A HIGHWALL

OF 60 FT IS CREATED AND TO MINE THE REQUIRED TONNAGE OF COAL, 1599
1705 FT OF HIGHWALL (BENCH LENGTH) ARE GENERATED. THUS, FOR 1699
A SPOIL BANK WITH A MEAN HEIGHT OF 45 FT, THE PILE REACHES 1799
95.9 FT DOWNSLOPE FROM THE OUTCROP AND ENCOMPASSES AN AREA 1899
OF 3.75 AC/1.0E12 BTU IN. 1999
THE DRAINAGE DITCH ABOVE THE HIGHWALL IS ASSUMED TO AFFECT 2099
50 FT UPSLOPE, HENCE, AN ADDITIONAL 1.96 AC/1.0E12 BTU IN 2199
OF LAND IS AFFECTED. 2299
CALCULATIONS FROM DATA COLLECTED IN EASTERN KENTUCKY (1029, 2399
1030,1031,1032,1033,1034) INDICATE THAT LAND AFFECTED BY 2499
LANDSLIDES AMOUNT TO 11.4 PC OF THE OUTSLOPE AREA COVERED BY 2599
THE SPOILS. THUS, AN ADDITIONAL LAND ACREAGE OF 0.428 AC/ 2699
1.0E12 BTU IN IS DAMAGED. (IT IS RECOGNIZED THAT THIS WILL 2799
NOT BE THE CASE FOR ALL MINES. SOME STATES REQUIRE PRACTICES 2899
THAT MINIMIZE THE OCCURRENCE OF LANDSLIDES. OBSERVATIONS 2999
INDICATE THAT THE OCCURRENCE OF LANDSLIDES IS SIGNIFICANTLY 3099
REDUCED WHEN THE SPOIL PILES ARE STABILIZED.) 3199
ALTHOUGH RECLAMATION PRACTICES ARE EMPLOYED, NOT ALL STATES 3299
HAVE MANDATORY VEGETAL SURVIVAL RATE REQUIREMENTS (1028) NOR 3399
ARE THERE STIPULATIONS FOR RECLAMATION OF TOP SOIL. THUS, 3499
EXCEPT FOR COVERING THE EXPOSED SEAM AND THE PIT FLOOR, NO 3599
RECLAMATION IS ASSUMED. 3699
THE TOTAL LAND USAGE IS 12.0 AC/1.0E12 BTU IN. THE TIME 3799
AVERAGED (OVER 25 YRS) LAND IMPACT IS THEREFORE 150 AC-YR/ 3899
1.0E12 BTU IN. 3999

1414 199

FOR A SLOPE ANGLE OF 20 DEGREES, A BENCH WIDTH OF 150 FT AND 299
A 15 FT RIM OF BLOSSOM COAL (FOOTNOTE 1413), 4.19E5 T OF 399
EARTH ARE MOVED PER 1.0E12 BTU IN. 499
AS A REQUIREMENT OF BACKFILLING, IT IS ASSUMED THAT 4 FT OF 599
MATERIAL, ABOVE THE HEIGHT OF THE COAL, MUST BE REPLACED. 699
THUS, FOR A 3.9 FT SEAM THICKNESS (FOOTNOTE 1406), 5.12E4 799
T/1.0E12 BTU IN SPOILS ARE REPLACED FOR BACKFILLING THE BENCH. 899
999
THE SOLID WASTE PRODUCTION IS, THEREFORE,3.68E5 T PER 1099
1.0E12 BTU IN. 1199

1415 199

THE AVERAGE DISTANCE FROM MINE TO TIPPLE IN THIS REGION IS 7.3 299
MI. (0001,344) AND DATA FROM STUDIES CONDUCTED IN EASTERN 399
KENTUCKY (1024,1031,1032,1033,1034) INDICATE A MEAN HAULAGE 499
ROAD RIGHT-OF-WAY OF 53 FT (6.4 AC/MI). THUS, THE HAULAGE 599
ROAD OCCUPIES 46.7 AC. ASSUMING AN ANNUAL PRODUCTION FROM 699
THE MINE OF 2 MMT (FOOTNOTE 1405), 2.1 PC OF THE ROAD USAGE 799
IS ATTRIBUTED TO THE TRANSPORT OF 1.0E12 BTU EQUIVALENT T. 899
THE LAND IMPACT IS, THEREFORE .990 AC-YR/1.0E12 BTU. 999

1416 199

IN AN EASTERN KENTUCKY STUDY,THE SEDIMENT YIELD FROM A COAL HAUL 299
ROAD WAS DETERMINED TO BE 90 T/AC-YR (1020,C32). BECAUSE OF 399
THE CONDITIONS,THE YIELD WAS EXCEPTIONALLY HIGH. FOR THE 499
PRESENT COMPUTATION IT IS ASSUMED THAT THE SEDIMENT YIELD 599
AVERAGES TO 35 T/AC-YR. THUS, 34.6 T/1.0E12 BTU OF SEDIMENT 699
IS YIELDED (FOOTNOTE 1415, LAND USE BY HAULAGE ROADS). 799

1417 199

IN 1969 THE AVERAGE TRUCK CAPACITY FOR THIS REGION WAS 22 T AND 299
THE AVERAGE HAULAGE DISTANCE FROM MINE TO TIPPLE WAS 7.3 MI 399
(0001,344). THE FUEL CONSUMPTION RATE IS ASSUMED TO BE 7 GAL/ 499
1000 TMI (0002,3-7). ASSUMING A GROSS TO TARE WEIGHT RATIO OF 599
2.5 FOR THE TRUCKS. A ROUND TRIP IS 375 TMI. SINCE 1927 699
ROUND TRIPS ARE REQUIRED TO HAUL 1.0E12 BTU EQUIVALENT T,5060 799
GAL OF DIESEL FUEL IS CONSUMED. THE EMISSIONS BREAKDOWN FOR A 899

DIESEL POWERED TRUCK IS GIVEN IN REF. (0002,3-7).
DUSTING FROM HAULAGE ROADS IS CONTROLLED BY WATERING DOWN, OILING,OR SOME OTHER METHOD.

1418

FUEL CONSUMPTION BY THE HAULAGE TRUCKS AMOUNTS TO 5060 GAL/1.0E12 BTU (FOOTNOTE 1417). THUS, THE ENERGY CONSUMPTION IS 7.02E8 BTU.

1419

THE CONVEYOR SYSTEM CONSUMES 1.03E6 KWH/YR OR ABOUT 21800 KWH/ 1.0E12 BTU (FOOTNOTE 1049). THE REAL ENERGY CONSUMPTION (2.23E8 BTU) IS 3 TIMES THE ELECTRICAL ENERGY CONSUMPTION.

1420

A CRUSHER OPERATING AT 275 T/HR AND CRUSHING TO A TOPSIZE OF 1.5 IN. REQUIRES A 140 HP MOTOR (1014,7-14). THUS, 1.61E4 KWH OF ENERGY ARE UTILIZED TO CRUSH 1.0E12 BTU EQUIVALENT T OF COAL. THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER UTILIZATION.

1421

IT IS ASSUMED THAT 0.006 PC OF THE FEED TO THE PREPARATION PLANT IS REMOVED AS TRAMP IRON. HENCE, 2.54 T OF TRAMP IRON IS COLLECTED FOR EVERY 1.0E12 BTU EQUIVALENT T PROCESSED. THE PERCENTAGE OF TRAMP IRON IS ESTIMATED FROM INFORMATION IN REF. (1059,6-31) ASSUMING THAT THE LARGE PLANT PROCESSED 1000 T/HR. OF COAL.

1422

THE DENSE MEDIUM BATH IS ASSUMED TO BE WASHING AT A SPECIFIC GRAVITY OF 1.6, AS FOR THE STEAM COAL PREPARATION PLANT (FOOTNOTE 1426). THE FEED TO THE BATH IS 1.5 X 3/8 IN. SIZED COAL AND IS ASSUMED TO HAVE THE CHARACTERISTICS OF THE AVERAGE UTILITY COAL FOR THIS REGION, I.E., 14.7 PC ASH AND 3.07 PC SULFUR (THIS AVERAGE ALSO INCLUDES MARYLAND, (1053,9)). SINCE THE CHARACTERISTICS OF THE LOWER KITANNING BED IN ARMSTRONG COUNTY, PA. ARE SIMILAR TO THOSE OF THE REGIONAL AVERAGE, THE WASHABILITY DATA FOR THIS COAL (1053,147)ARE USED IN THIS ANALYSIS. THE SCREEN ANALYSIS WAS OBTAINED FROM REF. (1055). THE THEORETICAL CLEAN COAL RECOVERY IS 83 PC. THE AVERAGE RECOVERY EFFICIENCY FOR A DENSE MEDIUM VESSEL IS ABOUT 97 PC (1054). THUS, THE YIELD AT A WASH SPECIFIC GRAVITY IS ESTIMATED TO BE 80.5 PC, WHICH IMPLIES A SOLID WASTE PRODUCTION OF 8270 T/1.0E12 BTU EQUIVALENT T PROCESSED.
THE SCREEN ANALYSIS FOR THIS COAL INDICATE THAT 1 PC OF THE 1.5 X 0 IN. CRUSHED COAL ARE CONTAINED IN THE SIZE FRACTION LESS THAN 100 MESH IN SIZE. A PORTION OF THIS SIZE FRACTION IS FED TO THE DENSE MEDIUM BATH DUE TO IMPERFECT SIZE SEPARATION. THUS, IT IS ASSUMED THAT 10 PC OF THE COAL LESS THAN 100 MESH IN SIZE ENDS UP AS BLACKWATER DISCHARGE FROM THE DENSE MEDIUM CIRCUIT. THIS AMOUNTS TO A SUSPENDED SOLIDS DISCHARGE OF 42.4 T/1.0E12 BTU EQUIVALENT T PROCESSED.
MAGNETITE LOSSES AMOUNT TO 0.9 LB/T OF CLEAN COAL PRODUCED (1054). THUS, AN ADDITIONAL 15.4 T OF SOLID WASTE IS PRODUCED/ 1.0E12 BTU PROCESSED.

1423

THE BTU WASHING EFFICIENCY FOR THE DENSE MEDIUM BATH, I.E., THE RATIO OF THE CALORIC CONTENT OF THE INPUT COAL AND THE OUTPUT COAL MULTIPLIED BY THE YIELD, DEPENDS ON THE ASH CONTENT OF THE FEED COAL AS WELL AS THE SPECIFIC GRAVITY OF THE WASH AND THE SIZE DISTRIBUTION WASHED. THE FOLLOWING EFFICIENCY EQUATION IS DEVELOPED FROM AVERAGED DATA IN (1010) USING A SPECIFIC GRAVITY FOR WASHING OF 1.6

PC BTU EFFICIENCY = -0.342(PC ASH) + 100

THUS, FOR AN ASH CONTENT OF 14.7PC(FOOTNOTE 1422) THE EFFICIENCY IS 95.0 PC.

1424

ENERGY CONSUMPTION AT A CRUSHING AND SIZING PLANT IS ABOUT 1.72E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION,1.5E5 KWH IS ELECTRICITY (1064,12A-16,39) AND 2.42E8 BTU IS OIL (1064,12A-16,39, ASSUMING ALL FUEL PURCHASED TO BE OIL AT A COST OF $0.20/GAL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL-CONSUMPTION TO THE OIL USAGE.

1425

APPROXIMATELY 35 AC OF LAND IS UTILIZED FOR THE CRUSHING AND SIZING PLANT AND A 10000 T UNIT TRAIN LOADING FACILITY (1021). THUS, THE LAND IMPACT IS 0.741 AC-YR/1.0E12 BTU.
IT IS ASSUMED THAT THE MODES OF TRANSPORT OTHER THAN UNIT TRAINS HAVE SIMILAR LAND REQUIREMENTS.

1426

THE PREPARATION PLANT PROCESSES 500 T/HR OF R.O.M. COAL. THE COAL IS CRUSHED TO A TOPSIZE OF 1.5 IN. THE 1.5 X 3/8 IN. SIZE FRACTION IS WASHED IN A DENSE MEDIUM VESSEL AT A SPECIFIC GRAVITY OF 1.6, WHILE THE COAL LESS THAN 3/8 IN. IN SIZE IS NOT SUBJECTED TO ANY CLEANING.
THE WASHABILITY DATA FOR THE LOWER KITANNING BED IN ARMSTRONG COUNTY, PA., ARE USED IN THIS ANALYSIS SINCE THE CHARACTERISTICS OF THIS COAL ARE SIMILAR TO THE THAT OF THE AVERAGE UTILITY COAL FOR THIS REGION, I.E., 14.7 PC ASH AND 3.07 PC SULFUR (FOOTNOTE 1422).
THE SCREEN ANALYSES FOR THIS COAL INDICATE THAT 28 PC OF THE CRUSHED COAL ARE LESS THAN 3/8 IN. IN SIZE. THUS, THE DENSE MEDIUM BATH WASHES 360 T/HR OF 1.5 X 3/8 IN. SIZED COAL.
THE WASHABILITY DATA INDICATE A THEORETICAL RECOVERY OF 83 PC. FOR A RECOVERY EFFICIENCY OF 97 PC (1054), THE ACTUAL WASHED COAL RECOVERY IS 80.5 PC. THIS IMPLIES THAT FOR EVERY 1.0E12 BTU EQUIVALENT T OF COAL PROCESSED,5960 T OF REFUSE ARE GENERATED.
MAGNETITE LOSSES AMOUNT TO 0.9 LB/T OF CLEAN COAL OUTPUT FROM THE BATH (1054). THUS, AN ADDITIONAL 11.0 T/1.0E12 BTU OF SOLID WASTE ARE PRODUCED. THE COLLECTION OF TRAMP IRON AMOUNTS TO 2.54 T/1.0E12 BTU BASED ON .006 P OF THE FEED TO THE PREP PLANT.

1427

THE LAND REQUIRED FOR THE PREPARATION PLANT IS ABOUT 5 AC (1008). THE LOADING AREA FOR A 10000 T UNIT TRAIN IS ESTIMATED TO BE ABOUT 40 AC (DATA ON THE MATTHEWS MINE, (1006,85)) AND THE SETTLING POND OCCUPIES ABOUT 50 AC (1009). THE PLANT PROCESSES 2 MMT/YR. THUS THE LAND IMPACT IS 2.01 AC-YR/1.0E12 BTU.
IN A PILE 30 FT HIGH THE REFUSE (FOOTNOTE 1426) OCCUPIES .0915 AC. THE TIME AVERAGED (OVER THE 25 YRS LIFE EXPECTANTCY OF THE PLANT) LAND IMPACT IS 1.14 AC-YR/1.0E12 BTU.

1428

THE BTU EFFICIENCY OF THE DENSE MEDIUM BATH WHICH WASHES 72 PC OF THE FEED IS 95 PC, WHILE THE EFFICIENCY FOR THE UNWASHED PORTION (28 PC) IS 100 PC (SEE FOOTNOTE 1423). THUS, THE WEIGHTED AVERAGE EFFICIENCY FOR THE PLANT IS 96.4 PC.

1429

ENERGY CONSUMPTION AT THE PREPARATION PLANT IS 2.17E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION 1.65E5 KWH ARE ELECTRICAL ENERGY AND 4.83E8 BTU ARE OIL (ASSUMING ALL FUELS PURCHASED TO BE OIL AT $.20/GAL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICITY CONSUMPTION TO THE OIL USE.

1430

A MAJORITY OF THE ACTIVE AND INACTIVE COAL WASTE BANKS SURVEYED (1067,1068) WERE FOUND BURNING OR SMOLDERING, ADDING TO THE PROBLEM OF AIR POLLUTION. IT IS ASSUMED THAT THE REFUSE BANK IN THIS CASE IS BURNING. THE EMISSION FACTORS ARE DETERMINED FROM INFORMATION IN REF. (0017) AND FROM THE KNOWLEDGE OF THE SOLID WASTE PRODUCED (FOOTNOTE 1426).

SINCE THE INTERMEDIATE AND FINE SIZE COALS ARE NOT SUBJECTED TO ANY CLEANING,THE ASSOCIATED PROBLEMS ARE NON-EXISTENT.

THE PROBLEM OF FUGITIVE DUST AT THE PREPARATION PLANT IS NOT SIGNIFICANT IN TERMS OF AIR POLLUTION BUT MAY BE AN OCCUPATIONAL HEALTH PROBLEM (1048).

1431

THE SEEPAGE FROM THE REFUSE PILE IS ASSUMED TO OCCUR AT A RATE OF 1670 GAL/AC-DAY AND CONTAINS 0.091 LB OF ACIDITY/GAL, 0.144 LB SULFATE/GAL, 0.0258 LB IRON/GAL AND 3.78E-4 LB MANGANESE/GAL (1009). THE DISCHARGE IS THEREFORE CONSTITUTED AS FOLLOWS (FOOTNOTE 1427).

	T/1.0E12 BTU
FE	9.0
SO4	50.1
MN	0.1
TOTAL	59.2
ACIDITY	31.6

THE SEDIMENT YIELD FROM THE REFUSE PILE OCCURS AT A RATE OF 2.54 T/AC-YR-IN. OF RUNOFF. THUS, FOR A 20 IN. RUNOFF THE SEDIMENT YIELD IS 58.0 T/1.0E12 BTU. (FOOTNOTE 1427, LAND USE BY REFUSE PILE)

OF THE RAW CRUSHED COAL 1 PC IS LESS THAN 100 MESH IN SIZE (1055). A PROPORTION OF THIS SIZE FRACTION ENDS UP IN THE FEED TO THE DENSE MEDIUM CIRCUIT. ASSUMING 10 PC OF THE COAL LESS THAN 100 MESH IN SIZE IS YIELDED AS BLACKWATER DISCHARGE, SUSPENDED SOLIDS ARE GENERATED AT A RATE OF 0.50 T/HR. IT IS UNREALISTIC TO ASSUME THAT ALL OF THE BLACKWATER IS DISCHARGED TO THE NATURAL DRAINAGE SINCE SOME PLANTS DO HAVE CONTROLS. IN THIS CASE IT IS ASSUMED THAT 37.5 PC OF THE PLANTS IN THIS REGION HAVE TREATMENT FACILITIES (AS IS THE CASE FOR THE COUNTRY (1112)). HENCE, ONLY 62.5 PC OF THE BLACKWATER GENERATED ENTERS NATURAL DRAINAGE. CONCEPTUALLY, FOR THIS SPECIFIC PLANT, THE BLACKWATER IS DISCHARGED THROUGH LEAKS, OVERFLOWS AND IMPROPER SETTLING. THE DISCHARGE OF SUSPENDED SOLIDS THEREFORE AMOUNTS TO .312 T/HR, OR 26.5 T/1.0E12 BTU (FOOTNOTE 1426).

1432

IN A STUDY OF UNIT TRAINS CONDUCTED BY THE BUR OF MINES (1006) THE AVERAGE HAULAGE DISTANCE FROM MINES IN THIS REGION WAS ABOUT 320 MI. THIS FIGURE IS USED FOR THIS ANALYSIS.
ENERGY CONSUMPTION BY FREIGHT TRAINS, ASSUMED TO APPLY AS WELL TO UNIT TRAINS, IS 690 BTU/TMI (FOOTNOTE 7013), OR .005 GAL OF DIESEL FUEL/TMI (5.825E6 BTU/BBL). FROM DATA IN (0021,31) THE ENERGY CONSUMPTION ASSUMES AN AVERAGE OF 3 LOCOMOTIVES PER TRAIN. THE GROSS TO TARE WEIGHT RATIOS OF THE CARS IS 4 TO 1 (FOOTNOTE 1005). HENCE, THE HAULAGE FOR EACH ROUND TRIP IS 5.34E6 TMI AND 1.13E5 GAL OF FUEL IS CONSUMED TO TRANSPORT 1.0E12 BTU EQUIVALENT T. THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7). (UNIT TRAIN CARRIES 10000 T/TRIP.)
WINDAGE LOSSES AMOUNT TO .04 PC OF THE TONNAGE HAULED AND ARE ACCOUNTED FOR MAINLY DURING HANDLING AT THE END POINTS.
THUS, 17 T OF PARTICULATES ARE RELEASED/1.0E12 BTU.

1433

THE FUEL CONSUMPTION BY UNIT TRAINS IS 1.13E5 GAL/1.0E12 BTU.
THUS, 1.58E10 BTU OF ENERGY IS CONSUMED. (FOOTNOTE 1432)

1434

THE TOTAL MILES OF RAILROAD OPERATED IN THE EASTERN DISTRICT (DIVISIONS MADE BY ICC,(0033,II)) IS 54000 MI (0033,59). THUS, FOR A RIGHT-OF-WAY OF 6 AC/MI (FOOTNOTE 1027) THE TOTAL LAND USAGE IS 324,000 AC.
OF THE TOTAL TONNAGE OF FREIGHT HAULED IN 1971, COAL ACCOUNTED FOR 43 PC OR 214E6 TON. OF THIS 30.6 PC OR 65.5E6 TON ORIGINATED FROM THIS REGION (0039,27 AND 1004,52,53). HENCE, 27.6 AC-YR/1.0E12 BTU IS ATTRIBUTED TO THE HAULAGE OF COAL FROM THIS REGION.

1435

IN THE EASTERN DISTRICT (0033,II),RAILWAY ACCIDENTS CLAIMED 705 LIVES, INJURED 9304 PERSONS (0006,17,54) AND AN AVERAGE OF 93 MAN-DAYS WERE LOST PER INJURY (0006,4).
OF THE TOTAL KILLED AND INJURED,0.0648 FATALITIES AND 0.856 NON-FATAL INJURIES ARE ATTRIBUTED TO THE TRANSPORT OF 1.0E12 BTU EQUIVALENT T FROM THIS REGION. FOR THE SAME HAULAGE 79.6 MAN-DAYS ARE LOST. (FOOTNOTE 1434, COAL TRANSPORTED)

1436

THE AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 320 MI AND FUEL CONSUMPTION IS 0.005 GAL/TMI (FOOTNOTE 1432). ASSUMING 1000 T COAL CARRIED PER MIXED TRAIN, ACCOUNTING FOR 20 PC OF THE TOTAL MIXED TRAIN SHIPMENT, A GROSS TO TARE WEIGHT RATIO OF 4/1 AND ONLY ONE WAY DIESEL FUEL CONSUMPTION ATTRIBUTED TO COAL, 30700 GAL OF DIESEL FUEL CONSUMPTION IS ATTRIBUTED TO THE HAULAGE OF 1.0E12 BTU EQUIVALENT T OF COAL. THE EMISSION FACTORS ARE COMPUTED FROM INFORMATION ON DIESEL LOCOMOTIVES IN (0002,3-7).
THE WINDAGE LOSSES ARE ASSUMED TO BE APPROXIMATELY .08 PC OF THE TOTAL SHIPMENT. HENCE ABOUT 33.9 T ARE RELEASED TO THE ATMOSPHERE AS PARTICULATES. (MOST OF THESE LOSSES OCCUR DURING HANDLING AT EITHER ENDPOINT.)

1437

DIESEL FUEL CONSUMPTION AMOUNTS TO 90700 GAL/1.0E12 BTU. THUS, THE ENERGY CONSUMPTION IS 1.26E10 BTU. (FOOTNOTE 1436)

1438

THE AVERAGE CAPACITY OF A BARGE IS 25000 T (1005,34), AND THE AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 800 MI (THE APPROXIMATE DISTANCE FROM ERIE, PA. TO CHICAGO VIA THE GREAT LAKES). THE EMISSION FACTORS ARE COMPUTED FROM DATA ON MOTORSHIPS UNDERWAY IN (0002,3-11).

THE WINDAGE LOSSES (OCCURING MAINLY DURING HANDLING AT EITHER END POINT) ARE ASSUMED TO BE .04 PC OF THE TOTAL SHIPMENT AS IN THE CASE FOR UNIT TRAINS. THUS, 17 T OF COAL FINES ARE EMITTED AS PARTICULATES.

1439

A BARGE CONSUMES 378 BTU/TMI (FOOTNOTE 7001). THUS, FOR AN AVERAGE HAULAGE DISTANCE OF 800 MI (FOOTNOTE 1438), A BARGE CAPACITY OF 25000 T AND ASSUMING A GROSS TO TARE WEIGHT RATIO OF 4 TO 1, THE ENERGY CONSUMPTION IS 2.13E10 BTU FOR EACH 1.0E12 BTU EQUIVALENT T TRANSPORTED.

1440

DURING THE TRANSPORT OF FOSSIL FUELS BY RIVER BARGES IN 1971, 3 FATALITIES AND 5 NON-FATAL INJURIES OCCURED (1049). IN THE SAME YEAR 70P OF THE TOTAL TONNAGE OF FOSSIL FUEL SHIPPED WAS COAL (0031,37,40). THUS, 1.93E-3/1.0E12 BTU FATALITIES AND 3.21E-3/1.0E12 BTU INJURIES ARE ATTRIBUTED TO THE TRANSPORT OF COAL.

THE AVERAGE DAYS LOST PER INJURY FOR MARINE CARGO HANDLERS FOR THE PERIOD FROM 1965-1967 IS 75.7 (0038,375). HENCE 0.243 DAYS LOST/1.0E12 BTU HANDLED.

THESE ARE NATIONAL AVERAGE FIGURES. NO REGIONAL DATA HAVE BEEN LOCATED.

1441

WHEN TRUCKS ARE UTILIZED IT IS USUALLY FOR SHORT HAULAGE DISTANCES THAT AVERAGE ABOUT 10 MI (1013). ASSUMING AN AVERAGE TRUCK CAPACITY OF 20 T, A GROSS TO NET WEIGHT RATIO OF 2.5 TO 1, AND A FUEL CONSUMPTION RATE OF 7 GAL/1000 TMI, 6900 GAL OF DIESEL FUEL IS CONSUMED. THE EMISSIONS FROM A DIESEL ENGINE ARE GIVEN IN (0002,3-7). IT IS ASSUMED THAT .04 PC OF THE TOTAL SHIPMENT IS LOST DUE TO WINDAGE (FOOTNOTE 1432). THE AMOUNT RELEASED AS PARTICULATES IS THEREFORE 17 T.

1442

THE LAND USE BY DIESEL FREIGHT TRUCKS IS 1.67E-6 AC/TMI (FOOTNOTE 7026). THUS, THE LAND IMPACT ATTRIBUTED TO THE HAULAGE OF THE COAL BY TRUCK IS 1.67 AC-YR/1.0E12 BTU (FOOTNOTE 1441).

1443

DIESEL FUEL CONSUMPTION AMOUNTS TO 6900 GAL/1.0E12 BTU. THUS, THE ENERGY CONSUMPTION IS 9.58E8 BTU. (FOOTNOTE 1441)

1444

THESE OCCUPATIONAL HEALTH STATISTICS ARE NATIONAL AVERAGES (FOOTNOTE 1061). NO REGIONAL DATA HAVE BEEN LOCATED.

1445

IT IS ASSUMED THAT THE AVERAGE CONVEYOR LENGTH IS 5 MI (FOOTNOTE 1335). HENCE, FOR A RIGHT-OF WAY OF 30 FT, 18.2 AC OF LAND IS OCCUPIED. THE SYSTEM TRANSPORTS 2 MMT/YR. THEREFORE IN TERMS OF ENERGY, 0.386 AC-YR/1.0E12 BTU OF LAND IS IMPACTED.

1446

ELECTRICAL ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYERS IS 3.65E4 KWH/1.0E12 BTU (FOOTNOTE 1053). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF ELECTRICAL ENERGY CONSUMPTION.

1447

STORAGE OF THE COAL IN A PILE AVERAGING 30 FT IN HEIGHT REQUIRES THE USE OF 0.763 AC-YR/1.0E12 BTU. IT IS ASSUMED THAT UNDERGROUND STORAGE ALSO REQUIRES THE SAME AMOUNT OF LAND.

1448

GENERALLY, SILOS HAVE A DIAMETER OF 70 FT AND ARE ABOUT 150 FT IN HEIGHT. THE STORAGE CAPACITY IS APPROXIMATELY 11000 T (1006). THUS, 4 SILOS ARE REQUIRED FOR STORING 1.0E12 BTU EQUIVALENT T. THE LAND IMPACTED BY THE SILOS IS THEREFORE 0.354 AC-YR/ 1.0E12 BTU.

1449

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYORS FOR STORAGE AMOUNTS TO 1.55E4 KWH/1.0E12 BTU (FOOTNOTES 1058,1059, 1060). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMED.

1450

THE OCCUPATIONAL HEALTH STATISTICS ARE OBTAINED FROM (1210,80/91 AND 1070) AND REPRESENT AN AVERAGE FOR 1969 AND 1970. THESE FIGURES DO NOT INCLUDE INJURIES RESULTING DURING HAULAGE.

1451

THE OCCUPATIONAL HEALTH STATISTICS FOR HAULAGE FROM MINE TO TIPPLE ARE OBTAINED FROM (1210,80/91 AND 1070) AND REPRESENT AN AVERAGE FOR 1969 AND 1970. THESE FIGURES INCLUDE HAULAGE FROM UNDERGROUND AND STRIP MINES. THE DATA COULD NOT BE DISAGREGATED BY METHOD OF HAULAGE, AND THUS WERE SUMMED. THE AVERAGE SEVERITY (MAN-DAYS LOST/INJURY) IS 28, WHICH IS AN AVERAGE BETWEEN UNDERGROUND AND STRIP MINES.

1452

THE OCCUPATIONAL HEALTH STATISTICS ARE OBTAINED FROM (1210,80/91 AND 1070) AND REPRESENT AN AVERAGE FOR 1969 AND 1970. THESE FIGURES INCLUDE ALL TYPES OF PREPARATION PLANTS.

CONTROLLED

FUEL	REGION
COAL	NORTHERN APPALACHIA B

ROW	MNE-MON	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL BTU/10^{12}BTU	13 PARTIC-ULATES	14 NO_x
			WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL 12)													
1	EXTRC	EXTRACTION														
2	UNDER	UNDERGROUND														
3	ROOM	ROOM & PILLAR	0.00+00 1 1463	1.10+00 4 1463	0000	0000	3.09+01 3 1463	3.99+01 4	5.95+01 2 1463	0000	4.05+01 4	0000	0.00+00 1 0997	0000	0.00+00 1 1014	0.00+00 1 1014
4	LONGW	LONGWALL	0.00+00 1 1463	1.72+00 4 1463	0000	0000	5.94+01 3 1463	5.94+01 4	8.87+01 2 1463	0000	6.03+01 4	0000	0.00+00 1 0997	0000	0.00+00 1 1014	0.00+00 1 1014
5	SURFC	SURFACE														
6	STRIP	<15° SLOPE	0.00+00 1 1467	4.46+01 4 1467	0000	0000	1.50+01 3 1467	1.50+01 4	2.23+01 2 1467	0000	1.52+01 4	0000	0.00+00 1 0997	0000	4.48-02 5 1400	1.27+00 5 1400
7	STRIP	>15° SLOPE	0.00+00 1 1467	4.41+01 4 1467	0000	0000	1.48+01 3 1467	1.48+01 4	7.20+01 2 1467	0000	1.50+01 4	0000	0.00+00 1 0997	0000	7.02+02 5 1412	2.00+00 5 1412
8	TRNSP	TRANSPORTATION														
9	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0.00+00 3 1455	0000	0.00+00 3	0000	0000	0000	3.29-02 3 1417	9.36-01 3 1417
10	CONVY	CONVEYOR	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0.00+00 1 1012
11	MINRA	MINE RAIL	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1042	0.00+00 2 1042
12	PROCE	PROCESSING														
13	BREAK	PRIMARY BREAKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1008	0000
14	BCLEN	ROOM CLEANING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1008	0000
15	RWSIZ	RAW COAL SIZING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1008	0000
16	DMEDC	DENSE MEDIA (COARSE)	0000	0000	0000	0000	0000	0000	4.24+01 4 1422	0000	4.24+01 5	0000	0.00+00 1 0997	0000	0.00+00 2 1008	0000
17	BRKSZ	BREAKING AND SIZING	0000	0000	0000	0000	0.00+00 1 1078	0.00+00 1	0.00+00 1 1078	0000	0.00+00 1	0000	0000	0000	0.00+00 2 1077	0000
18	STRAM	STEAM COAL	0.00+00 2 1457	0000	0000	0000	0.00+00 3 1457	0.00+00 3	1.00+01 4 1457	0000	1.00+01 4	0000	0.00+00 1 0997	0000	0.00+00 3 1458	0.00+00 3 1458
19	DISTB	DISTRIBUTION														
20	UNITT	UNIT TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.64+01 4 1430	4.20+00 3 1430
21	MIXT	MIXED TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.50+01 5 1430	3.40+00 5 1430
22	BARGE	RIVER BARGE	0000	0000	0000	0000	0000	0000	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1.97+01 4 1430	1.00+00 4 1430
23	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.70+01 4 1441	1.20+00 4 1441
24	CONV	CONVEYORS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0000
25	STORA	STORAGE														
26	ACGND	ABOVE GROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0997	0000	0000	0000
27	UGRND	UNDER GROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0997	0000	0000	0000
28	SILOS	SILOS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1400 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF NORTHERN APPALACHIAN COAL AND REGIONAL DESCRIPTION.

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
		AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
COD	THERMAL BTU/10^{12} BTU	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/ 10^{12} BTU	LAND (ACRE-YR/ 10^{12} BTU)	DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	ROW
																	1
											8.89-03 1 1450	5.37-01 1 1450	1.89+01 1 1450				2
0997	0998	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	1.10+03 3 1461	1.30-02 3 1466	0999	0999	0999	1079	6.70-01 1 1091	4.47+00 5 1462	3
0997	0998	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	1.78+03 3 1461	2.88+02 3 1466	0999	0999	0999	1079	8.50-01 1 1090	6.02+00 5 1462	4
											4.81-03 1 1450	1.24-01 1 1450	2.49+00 1 1450				5
0997	0998	4.48-02 5 1400	1.27+00 5 1400	9.10-02 5 1400	1.37-01 5 1400	7.76-01 3 1400	2.07-02 5 1400	2.33+00 5	6.68+02 3 1465	1.69-01 4 1468	0999	0999	0999	1081	6.10-01 1 1094	5.94+00 5 1465	6
0997	0998	7.02-02 5 1412	2.00+00 5 1412	1.46-01 5 1412	2.00-01 5 1412	1.22+00 5 1412	3.24-02 5 1412	3.67+00 5	6.12+02 3 1465	2.79-01 4 1470	0999	0999	0999	1081	8.00-01 1 1095	1.10+10 5 1471	7
											5.47-03 2 1451	2.47-01 2 1451	6.92+00 3 1451				8
0998	0998	3.29-02 3 1417	6.36-01 3 1417	6.83-02 3 1417	8.36-02 3 1417	5.69-01 3 1417	1.52-02 3 1417	1.72+00 3	0999	1.14+00 3 1472	0999	0999	0999	1082	1.00+00 1 1099	7.02+00 3 1418	9
0998	0998	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1	0999	0.00+00 2 1013	0999	0999	0999	1083	1.00+00 1 1099	2.23+08 4 1419	10
0998	0998	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2 1042	0.00+00 2	0999	0.00+00 2 1042	0999	0999	0999	1083	1.00+00 1 1099	0999	11
											7.38-04 1 1452	4.62-02 1 1452	1.40+00 1 1452				12
0998	0998	0.00+00 2 1066	0998	0999	0999	0999	0999	0.00+00 2	0999	0999	0999	0999	0999	1102	1.00+00 1 1107	1.65+08 2 1438	13
0998	0998	0.00+00 2 1066	0998	0999	0999	0999	0999	0.00+00 2	2.54+00 3 1431	0999	0999	0999	0999	1102	1.00+00 1 1107	0999	14
0998	0998	0.00+00 2 1066	0998	0999	0999	0999	0999	0.00+00 2	0999	0999	0999	0999	0999	1102	1.00+00 1 1107	0999	15
0997	0998	0998	0998	0999	0999	0999	0999	0998	8.28+03 2 1427	0999	0999	0999	0999	1102	9.50-01 2 1423	0999	16
0998	0998	0.00+00 2 1077	0998	0999	0999	0999	0999	0999	2.54+00 3 1431	7.41-01 2 1423	0999	0999	0999	1102	1.00+00 1 1099	1.72+08 4 1434	17
0997	0998	0.00+00 3 1450	0.00+00 3 1450	0.00+00 3 1450	0.00+00 3 1450	0.00+00 3 1450	0.00+00 3 1450	0.00+00 3	8.82+03 3 1450	2.23+00 3 1400	0999	0999	0999	1102	8.64-01 2 1429	2.20+00 4 [illegible]	18
																	19
0998	0998	1.64+01 4 1432	4.28+00 1 1432	3.71+00 3 1432	2.93+00 3 1432	4.00+00 3 1432	6.27-01 3 1432	3.39+01 3	0999	2.76+01 3 1434	6.40-02 3 1435	8.50-01 3 1435	7.98+01 3 1435	1103	1.00+00 3 1001	1.96+10 3 1433	20
0998	0998	1.50+01 5 1430	3.40+00 5 1430	2.91+00 5 1430	2.27+00 5 1430	3.17+00 5 1430	4.98-01 5 1430	4.73+01 5	0999	2.76+01 3 1434	6.40-02 3 1435	8.50-01 3 1435	7.98+01 3 1435	1103	0.90+01 3 1001	1.28+10 3 1437	21
0997	0998	1.97+01 4 1430	1.90+00 4 1430	2.04+00 4 1430	1.22+00 4 1430	1.63+00 4 1430	9.50-02 4 1430	2.66+01 4	0999	0998	1.93-03 5 1440	3.21-03 5 1440	2.43-01 5 1440	1103	1.00+00 3 1001	2.13+10 4 1430	22
0998	0998	1.70+01 4 1441	1.28+00 4 1441	8.32-02 4 1441	1.28-01 4 1441	7.76-01 4 1441	2.07-02 4 1441	1.93+01 4	0999	1.67+00 4 1442	3.24-02 5 1444	6.82-01 5 1444	4.56+01 5 1444	1103	1.00+00 3 1001	0.58+08 4 1443	23
0998	0998	0.00+00 1 1012	0998	0999	0999	0999	0999	0.00+00 1	0999	3.80-01 5 1440	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1103	1.00+00 4 1003	3.76+08 4 1440	24
																	25
0997	0998	0999	0998	0999	0999	0999	0999	0999	0999	7.63-01 2 1447	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1103	9.00-01 2 1007	1.50+08 5 1440	26
0997	0998	0999	0998	0999	0999	0999	0999	0999	0999	7.63-01 2 1447	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1103	9.00-01 2 1007	1.50+08 5 1440	27
0998	0998	0998	0998	0999	0999	0999	0999	0999	0999	3.34-01 2 1440	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1103	9.00-01 2 1007	1.50+08 5 1440	28
																	29
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TABLE 8. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED NORTHERN APPALACHIA REGION OF COAL SUPPLY

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FOOTNOTES FOR TABLE 8

1455

SEDIMENT RUNOFF FROM COAL HAULAGE ROADS CAN BE CONTROLLED BY DITCHING ALONGSIDE THE ROADS AND DIVERTING THE RUNOFF TO SMALL SETTLING PONDS.

1456

EMISSIONS ASSOCIATED WITH THE BURNING COAL REFUSE PILE (FOOTNOTE 1430) ARE COMPLETELY ELIMINATED BY RECLAMATION OF THE REFUSE PILE. BAGHOUSES FOR CONTROL OF FUGITIVE DUST EMISSIONS ARE USED IN THE CONTROLLED UTILITY PREP PLANT IN ORDER TO COMPLY WITH THE 10P OPACITY LIMIT FOR VISIBLE EMISSIONS FROM NEW PREP PLANTS (1121).

1457

SEEPAGE FROM THE REFUSE PILE IS ASSUMED TO BE COMPLETELY ELIMINATED BY THE SOIL COVER ESTABLISHED IN RECLAIMING THE REFUSE PILE. RUNOFF FROM THE REFUSE PILE CONTINUES HOWEVER, BECAUSE OF THE 3 YEAR TIME LAG ASSOCIATED WITH ESTABLISHMENT OF AN HERBACEOUS COVER (FOOTNOTE 1103). BASED ON 2.54 TON SUSPENDED SOLIDS/ACRE-YR-IN RUNOFF AND ON 20 IN RUNOFF (SEE FOOTNOTE 1072) AND .215 ACRE-YR/1.0E12 BTU (FOOTNOTE 1460), 10.9 TON SUSPENDED SOLIDS/1.0E12 BTU ARE GENERATED IN RUNOFF FROM THE RECLAIMED REFUSE PILE. SUSPENDED SOLIDS GENERATED IN THE PREP PLANT ARE ELIMINATED BY THE USE OF A SETTLING POND.

1458

IT HAS NOT BEEN POSSIBLE TO QUANTIFY FUGITIVE DUST EMISSIONS FROM COAL PREP PLANTS. THUS IT IS NOT POSSIBLE TO QUANTIFY THE INCREMENTAL SOLID WASTE GENERATED BY THE USE OF BAGHOUSES TO CONTROL THESE EMISSIONS. THEREFORE, THE SOLID WASTE GENERATED IN THE CONTROLLED UTILITY COAL PREP PLANT IS THE SAME AS GIVEN IN FOOTNOTE 1426, NAMELY 5970 TON/1.0E12 BTU.

1459

THE TOTAL POWER REQUIREMENT FOR THE 7 BAGHOUSES IN A 500 TON/HR PREP PLANT IS 175 HP (1080,73) OR 4.55E05 KWH/YR (BASED ON 3480 HR/YR OPERATION). CONVERTING THIS BY 10200 BTU/KWH AND SIZING THE RESULT FOR A 1.0E12 BTU/YR PREP PLANT GIVES AN ENERGY REQUIREMENT OF 1.13E08 BTU/1.0E12 BTU. NO INFORMATION WAS AVAILABLE ON ENERGY REQUIREMENTS FOR REFUSE RECLAMATION. THE ENERGY REQUIRED FOR THE CLOSED CIRCUIT SETTLING POND IS BASED ON .0457 $/TON SUSPENDED SOLIDS (FOOTNOTE 1126), 42.4 T OF SOLIDS (FOOTNOTE 1431), AND $.01/KWH TO GIVE 1.935E02 KWH/ 1.0E12 BTU OR 1.98E06 BTU/1.0E12 BTU (CONVERTING AT 10200 BTU /KWH). THE SUM TOTAL INCREMENTAL ENERGY DEMAND ASSOCIATED WITH CONTROLS ON A 1.0E12 BTU/YR UTILITY COAL PREP PLANT IS THUS 1.15E08 BTU/1.0E12 BTU.

1460

BASED ON A SOLID WASTE PRODUCTION OF 5970 TON/1.0E12 BTU (FOOTNOTE 1426), A COMPACTED REFUSE DENSITY OF .06 TON/CF, AND A 30 FT HIGH REFUSE PILE, .076 ACRES OF LAND/1.0E12 BTU IS IMPACTED. BASED ON A 3 YEAR TIME LAG TO ESTABLISH AN HERBACEOUS COVER AND A 25 YR PLANT OPERATING LIFETIME, 2.82 TIMES THE YEARLY LAND IMPACT REPRESENTS THE TIME AVERAGED LAND IMPACT (FOOTNOTE 1103). THUS .215 ACRE-YR/1.0E12 BTU IS THE TIME AVERAGED LAND IMPACT. THE LAND REQUIREMENT FOR THE UTILITY COAL PREP PLANT IS 2.01 ACRE-YR/1.0E12 BTU (FOOTNOTE 1427) SO THAT THE TOTAL LAND REQUIREMENT IS 2.23 ACRE-YR/1.0E12 BTU.

1461

A HYDRATED LIME PROCESS IS UTILIZED FOR TREATMENT OF THE ACID DRAINAGE FROM THE DEEP MINE. ASSUMING AN ACID LOAD OF 3000 PPM,THE PLANT WILL HAVE TO PROCESS ABOUT 1.9 MMG/DAY (FOOTNOTE

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1404 MINE DRAINAGE POLLUTANT LOADS). THE TOTAL IRON CONCEN- 599
TRATION IS ABOUT 220 PPM. THUS, THE SOLID WASTE PRODUCTION IS 699
ABOUT 63.8 AC-FT/YR (1102,233). ASSUMING A PRECIPITATE DENSITY 799
OF 71 LB/CF (1114,288) SOLID WASTE IS GENERATED AT A RATE OF 899
98660 T/YR FOR A 2 MM TPY MINE. THUS,THERE IS AN ADDITIONAL 999
(TO THAT PRODUCED FROM THE MINING OPERATION) 1190 TON/1.0E12 1099
BTU IN FOR ROOM AND PILLAR MINES AND 1780 TON/1.0E12 BTU IN 1199
FOR LONGWALL MINING. 1299

1462 199

THE AVERAGE ANNUAL POWER EXPENSE FOR THE HYDRATED LIME SYSTEMS 299
UTILIZED IN OPERATION YELLOWBOY WAS ABOUT $16400/MMG/D (1102, 399
231). THUS AT A COST OF $0.015/KWH THE ENERGY REQUIREMENT TO 499
OPERATE THE 1.9 MMG/D HYDRATED LIME PLANT IS 2.07E6 KWH/YR, 599
OR 4.39E4 KWH/1.0E12 BTU OUT. THE REAL ENERGY CONSUMPTION IS 699
3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMED. 799
ON A 1.0E12 BTU IN BASIS,THE ENERGY CONSUMPTION IS 2.57E8 BTU 899
FOR ROOM AND PILLAR MINING AND 3.83E8 BTU FOR LONGWALL MINING.999
1099
THIS ENERGY USE IS IN ADDITION TO THE ENERGY EXPENDED FOR THE 1199
MINING OPERATION, I.E., 4.21E9 BTU AND 5.64E9 BTU/1.0E12 BTU 1299
IN FOR THE ROOM AND PILLAR, AND LONGWALL MINING, RESPECTIVELY 1399
(FOOTNOTE 1411). 1499

1463 199

IT IS ASSUMED THAT THE FINAL DISCHARGE WILL BE IN COMPLIANCE WITH 299
THE GUIDELINES ESTABLISHED BY EPA (1112). IN LIME TREATMENT, 399
BECAUSE OF THE SOLUBILITY OF CALCIUM SULFATE, THE HARDNESS OF 499
THE WATER WILL INCREASE (1113,24). MOST OF THE METALLIC SALTS 599
WILL PRECIPITATE AS THE PH OF THE SOLUTION IS RAISED. THE 699
EFFLUENT BREAKDOWN IS AS FOLLOWS 799

	PPM	ROOM AND PILLAR T/1.0E12 BTU IN	LONGWALL T/1.0E12 BTU IN	
				899
SUSPENDED SOLIDS	30	0.595	0.887	999
ACIDITY	0	0.00	0.00	1099
ALKALINITY	60	1.19	1.77	1199
				1299
IRON	4	0.079	0.118	1399
MN	4	0.079	0.118	1499
AL	1	0.020	0.030	1599
$CASO_4$	2000	39.7	59.1	1699
SUBTOTAL		39.9	59.4	1799
				1899
				1999

THE ALKALINITY CONCENTRATION IS OBTAINED FROM DATA IN 2099
(1103), THE MN AND AL FROM SOLUBILITY CURVES, WHILE THE 2199
REMAINDER ARE IN COMPLIANCE WITH THE EPA GUIDELINES. THE VOL- 2299
UME OF THE DISCHARGE IS ABOUT 85 PC OF THE INFLOW VOLUME 2399
(1103), I.E., 1.61 MMGAL/DAY, AND THE FACILITY OPERATES 2499
245 D/YR. 2599

1464 199

IT IS ASSUMED THAT THE TREATMENT FACILITY REQUIRES A 4 MMGAL RAW 299
WATER STORAGE POND AND A 400 MMGAL SETTLING POND. THE LAND 399
IS ASSUMED AVAILABLE. FOR A DEPTH OF 20 FT FOR BOTH PONDS, 499
61.6 AC OF SURFACE AREA ARE REQUIRED. THE TREATMANT PLANT 599
OCCUPIES ABOUT 3 AC (1114). THUS, THE TOTAL LAND IMPACT IS 699
0.781 AC-YR/1.0E12 BTU IN FOR ROOM AND PILLAR MINING AND 1.16 799
AC-YR/1.0E12 BTU IN FOR LONGWALL MINING. 899
THIS IS IN ADDITION TO THE LAND IMPACTED DURING MINING, I.E., 999
129 AC-YR/1.0E12 BTU IN FOR ROOM AND PILLAR MINING (FOOTNOTE 1099
1402) AND 285 AC-YR/1.0E12 BTU IN FOR LONGWALL MINING (FOOT- 1199
NOTE 1403). 1299

1465

A HYDRATED LIME PROCESS IS UTILIZED FOR TREATMENT OF THE ACID DRAINAGE FROM THE AREA STRIPPING OPERATION. ASSUMING AN ACID LOAD OF 1000 PPM THE PLANT WILL HAVE TO PROCESS 0.5 MMGAL/DAY (FOOTNOTE 1407, MINE DRAINAGE POLLUTANT LOADS). THE TOTAL IRON CONCENTRATION IS ABOUT 650 PPM. THE SOLID WASTE PRODUCTION FOR THE PLANT AMOUNTS TO ABOUT 11.9 AC-FT/YR (1102,233). ASSUMING A PRECIPITATE DENSITY OF 71 LB/CF (1114,288), SOLID WASTE IS GENERATED AT A RATE OF 18400 T/YR, OR 316 T/1.0E12 BTU IN FOR A 2 MM TPY MINE.
THIS IS IN ADDITION TO THE SOLID WASTE PRODUCED DURING MINING, I.E., 352 T/1.0E12 BTU IN (FOOTNOTE 1405).

1466

THE ENERGY REQUIREMENT TO OPERATE A 0.5 MMG/DAY HYDRATED LIME PLANT IS 0.550E6 KWH/YR, OR 9.39E3 KWH/1.0E12 BTU IN (FOOTNOTE 1462). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMED.
THE SPOILS ARE STACKED IN PILES ABOUT 50 FT HIGH. ASSUMING GEOMETRICALLY UNIFORM PARALLEL SPOIL PILES RESTING AT AN ANGLE OF REPOSE OF 38 DEGREES, THE PEAK TO PEAK DISTANCE IS ABOUT 70 FT. THUS THE ENERGY CONSUMED DURING THE LEVELING OF THE SPOIL BANKS AMOUNTS TO 1920 HP-HR/AC ((1222,67) AND ASSUMING A 6 PC PERFORMANCE EFFICIENCY), OR 2.87E7 BTU/1.0E12 BTU IN (FOOTNOTE 1406, LAND TO BE RECLAIMED).
THE ENERGY UTILIZED FOR WASTE WATER TREATMENT AND RECLAMATION IS IN ADDITION TO THE ENERGY USED DURING THE MINING OPERATION - 5.82E9 BTU/1.0E12 BTU IN (FOOTNOTE 1408).

1467

IT IS ASSUMED THAT THE FINAL DISCHARGE WILL BE IN COMPLIANCE WITH THE GUIDELINES ESTABLISHED BY EPA (1112). THE VOLUME OF DISCHARGE IS ABOUT 85 PC OF THE INFLOW VOLUME (1103), I.E., 0.425 MMGAL/DAY. THE EFFLUENT BREAKDOWN IS AS FOLLOWS (FOOTNOTE 1463).

	PPM	$<15^{o}$ T/1.0E12 BTU IN	$>15^{o}$ T/1.0E12 BTU IN
SUSPENDED SOLIDS	30	0.223	0.220
ACIDITY	0	0.0	0.0
ALKALINITY	60	0.446	0.441
IRON	4	0.030	0.029
MN	4	0.030	0.029
AL	1	0.007	0.007
$CASO_4$	2000	14.9	14.7
SUBTOTAL		15.0	14.8

THE FACILITY OPERATES 245 D/YR. IT SHOULD BE NOTED THAT THE PRODUCTION FROM A CONTOUR STRIPPING OPERATION IS USUALLY SMALL, AND A HYDRATED LIME SYSTEM AS DESCRIBED IN THESE FOOTNOTES MAY NOT BE ECONOMICALLY FEASIBLE. PROVIDING THE ACID CONCENTRATION AND THE DISCHARGE RATE IS LOW, A SODA ASH PROCESS OR SOME PORTABLE TYPE OF TREATMENT FACILITY MAY BE MORE FEASIBLE.

1468

FOR AREA STRIPPING (SLOPE LESS THAN 15 DEGREES) 5.87 AC OF LAND ARE OVERTURNED/1.0E12 BTU IN (FOOTNOTE 1406).

IN TIME AVERAGING THE LAND IMPACT,THE EFFECTS OF RECLAMATION 499
MUST BE CONSIDERED. RECLAMATION IN THIS CASE REQUIRES THE 599
RESTORATION OF THE LAND TO THE ORIGINAL CONTOUR (OR AS CLOSE 699
TO THE ORIGINAL CONTOUR AS POSSIBLE), AND STABILIZING THE 799
SURFACE AGAINST EROSION. MINIMIZING EROSION INVOLVES BENEFI- 899
CIAL GRADING (TERRACING, GOUGING, ETC.) AND ESTABLISHING AN 999
HERBACEOUS COVER. IN APPALACHIA ABOUT 3 GROWING SEASONS ARE 1099
REQUIRED TO ESTABLISH A 95 PC COVER OF GRASS AND LEGUMES 1199
(1101). 1299
USING THE 3 YR CRITERION THE TIME AVERAGED LAND IMPACT IS 1399
16.6 AC-YR/1.0E12 BTU IN. THE LAND IMPACT DUE TO THE WASTE PILE 1499
IS ASSUMED TO BE NIL, WHICH IMPLIES INSTANTANEOUS RECLAMATION. 1599
1699
IT IS ASSUMED THAT THE TREATMENT PLANT REQUIRES A 4 MMGAL RAW 1799
WATER STORAGE POND AND A 70 MMGAL SETTLING POND. THE LAND IS 1899
ASSUMED AVAILABLE. FOR AN AVERAGE DEPTH OF 20 FT FOR BOTH 1999
PONDS, ABOUT 11.8 AC OF SURFACE AREA ARE REQUIRED. THE TREAT- 2099
MENT PLANT OCCUPIES APPROXIMATELY 3 AC (1114). THUS, THE LAND 2199
IMPACT IS 0.254 AC-YR/1.0E12 BTU IN. 2299

1469 199

FOR THE MODIFIED BLOCK CUT MINING TECHNIQUE, SOLID WASTE IS 299
PRODUCED ONLY DURING THE BOX CUT. HENCE, FOR A SLOPE ANGLE OF 399
20 DEGREES, A BENCH WIDTH OF 150 FT., A 15 FT RIM OF BLOSSOM 499
COAL, AND A BOX CUT OF 600 FT IN LENGTH, 0.148 MMT OR 100 T/ 599
1.0E12 BTU IN OF SOLID WASTE ARE PRODUCED (SUBSEQUENT TO THE 699
BOX CUT 50 MMT OF COAL ARE REMOVED OVER A 25 YR PERIOD). THE 799
LENGTH OF THE BOX CUT IS BASED ON 250 FT LONG SECOND AND 899
THIRD CUTS (1104) AND ALLOWS FOR EXPANSION. 999
AN ADDITIONAL 312 T/1.0E12 BTU IN OF SOLID WASTE IS PRODUCED 1099
FROM THE HYDRATED LIME TREATMENT FACILITY WHICH IS IDENTICAL 1199
TO THE PLANT FOR THE AREA STRIPPING OPERATION (FOOTNOTE 1465). 1299

1470 199

FOR CONTOUR MINING (SLOPES GREATER THAN 15 DEGREES) IT IS ASSUMED 299
THAT THE MODIFIED BLOCK CUT METHOD IS EMPLOYED 399
THE THICKNESS OF THE SEAM IS 3.9 FT (FOOTNOTE 1413), THUS 499
5.87 AC ARE OVERTURNED FOR EVERY 1.0E12 BTU IN. AT THE SAME 599
TIME,1705 FT OF BENCH ARE CREATED (FOOTNOTE 1469). ASSUMING 699
50 FT STRIPS OF LAND ABOVE THE HIGHWALL AND ALONG THE OUT- 799
SLOPE ARE UTILIZED FOR THE DIVERSION DITCH AND FOR STOCK- 899
PILING THE TOPSOIL, RESPECTIVELY, ANOTHER 3.91 AC OF LAND ARE 999
EFFECTED PER 1.0E12 BTU IN. 1099
NOW,ASSUMING THAT 3 GROWING SEASONS ARE REQUIRED TO ESTABLISH 1199
AN HERBACEOUS COVER (FOOTNOTE 1460), THE TIME AVERAGED (OVER 1299
25 YRS) LAND IMPACT OF THE VARIABLE LAND USE (9.78 AC) IS 1399
27.6 AC-YR/1.0E12 BTU IN. 1499
THE SOLID WASTE GENERATED FROM THE BOX CUT (FOOTNOTE 1469) IS 1599
DISPOSED OF BY THE PARALLEL SLOPE METHOD. BY THE END OF 3 YRS 1699
THIS PLOT WILL BE RECLAIMED (AS MEASURED BY THE CRITERION IN 1799
FOOTNOTE 1460), THUS THE CONTRIBUTION TO THE OVERALL LAND 1899
IMPACT IS NEGLIGIBLE. THE LAND USE BY THE HYDRATED LIME 1999
TREATMENT FACILITY IS 0.251 AC-YR/1.0E12 BTU IN (FOOTNOTE 2099
1468). 2199

1471

THE ENERGY REQUIREMENT FOR STRIPPING BY THE MODIFIED BLOCK CUT IS NOT AVAILABLE,AND WAS ASSUMED TO BE THE SAME AS CONVENTIONAL CONTOUR STRIPPING - 1.09E10 BTU/1.0E12 BTU IN (FOOTNOTE 1410). THE ENERGY CONSUMED BY THE HYDRATED LIME TREATMENT FACILITY IS 9.27E3 KWH/1.0E12 BTU IN (FOOTNOTE 1466) OR 9.49E7 BTU/1.0E12 BTU IN.

1472

IT IS ASSUMED THAT A SETTLING POND IS REQUIRED FOR EACH MILE OF ROAD AND THAT EACH POND USES AN ACRE. THUS, 7 AC ARE UTILIZED FOR THE SETTLING POND (THE HAUL ROAD IS 7.3 MI IN LENGTH, FOOTNOTE 1415). THE LAND IMPACT IS 0.148 AC-YR/1.0E12 BTU. THIS IS IN ADDITION TO THE LAND IMPACTED BY THE ROAD - .990 AC-YR/1.0E12 BTU (FOOTNOTE 1415).

FUEL	REGION
COAL	CENTRAL APPALACHIA

UNCONTROLLED

ROW	NUMBER	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/10^{12} BTU)	13 PARTIC-ULATES	14 NO_x
			WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL 12)													
1	EXTRC	EXTRACTION														
2	UNDGR	UNDERGROUND														
3	ROOMP	ROOM & PILLAR	9.35+00 5 1503	0000	0000	0000	3.31+02 4 1503	3.31+02 4	2.72+02 3 1503	0000	3.31+02 4	0000	0.00+00 1 0007	0000	0.00+00 1 1016	0.00+00 1 101
4	AUGRS	AUGERS	1.80+00 4 1500	0000	0000	0000	2.12+01 5 1500	2.12+01 4	8.50+02 3 1500	0000	8.50+02 5	0000	0.00+00 1 0007	0000	4.06-02 5 1500	1.15+00 5 150
5	SURFC	SURFACE														
6	STRP+	> 10° SLOPE	5.20+00 3 1516	0000	0000	0000	3.60+01 4 1516	3.60+01 4	5.45+03 3 1516	0000	5.49+03 4	0000	0.00+00 1 0007	0000	6.82-02 5 1515	1.96+00 5 150
7	TRNSP	TRANSPORTATION														
8	TRUCK	TRUCK	0000	0000	0000	0000	0000	0000	2.22+01 4 1516	0000	2.22+01 4	0000	0000	0000	2.05-02 5 1517	5.86-01 4 151
9	CONVY	CONVEYOR	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0.00+00 1 101
10	MINBA	MINE BAR.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1042	0.00+00 1
11	PROCS	PROCESSING														
12	PRBRK	PRIMARY BREAKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	
13	RCLEN	ROUGH CLEANING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	
14	RWHZ	RAW COAL HEDNG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	
15	BRKRS	BRASCING & HEDNG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	
16	DSTRB	DISTRIBUTION														
17	UNITT	UNIT TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.81+01 5 1520	5.00+00 5
18	MIXT	MIXED TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.38+01 5 1520	2.80+00 5
19	BARGE	RIVER BARGE	0000	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	1.74+01 5 1520	6.09-01 5
20	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.64+01 5 1520	1.26+00 4
21	CONVY	CONVEYORS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	
22	STORA	STORAGE														
23	ABGRD	ABOVE GROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	
24	UGRND	UNDERGROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	
25	SILOS	SILOS OR BINS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
26																
27																
28																
29																
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY. SEE FOOTNOTE 1500 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF CENTRAL APPALACHIAN COAL AND REGIONAL DESCRIPTION.

HITTMAN

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	ROW
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12} BTU)	PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	
																1
																2
0000	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1 1016	0.00+00 1	1.40+00 2 1501	1.32+02 2 1502	1.24-02 1 1504	3.44-01 1 1504	1.95+01 1 1504	1018	3.70+[illegible] 1 1002	4.07+00 5 [illegible]	3
0000	4.04-02 5 1508	1.15+00 5 1508	8.40-02 5 1508	3.15-01 5 1508	7.00-01 5 1508	1.67-02 5 1508	2.11+00 5	3.03+04 2 1507	4.88+01 2 1508	1.02-03 3 1504	9.43-02 3 1504	1.90+00 3 1504	1002	6.00-01 1 1002	8.63+00 5 1512	4
										1.78-03 1 1504	1.44-01 1 1504	3.30+00 1 1504				5
0000	6.03-02 5 1513	1.04+00 5 1513	1.42-01 5 1513	1.04-01 5 1513	1.10+00 5 1513	3.15-02 5 1513	3.56+00 5	3.04+00 3 1516	1.95+02 2 1511	0000	0000	0000	1002	0.00-01 1 1002	1.06+10 [illegible] 1516	6
										3.18-03 2 1451	1.44-01 2 1451	4.00+00 2 1451				7
0000	2.00-02 5 1517	5.80-01 4 1517	4.20-02 6 1517	5.80-02 6 1517	3.50-01 6 1517	8.50-03 5 1517	1.07+00 5	0000	0.32-01 2 1515	0000	0000	0000	1002	1.00+00 1 1002	6.38+09 5 1516	8
0000	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1	0000	0.00+00 1 1012	0000	0000	0000	1002	1.00+00 1 1002	2.10+03 4 1516	9
0000	0.00+00 1 1042	0.00+00 1 1042	0.00+00 1 1042	0.00+00 1 1042	0.00+00 1 1042	0.00+00 1 1042	0.00+00 1	0000	0.00+00 1 1042	0000	0000	0000	1002	1.00+00 1 1002	0000	10
										3.02-04 1 1452	2.27-02 1 1452	7.90-01 1 1452				11
0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1002	1.00+00 1 1007	1.00+00 2 1520	12
0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	2.46+00 4 1521	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	13
0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	14
0000	0.00+00 2 1077	0000	0000	0000	0000	0000	0000	2.46+00 4 1521	7.24-01 2 1522	0000	0000	0000	1002	1.00+00 1 1000	1.00+00 4 1521	15
																16
0000	1.81-01 5 1526	5.06+00 5 1526	4.30+00 5 1526	3.38+00 5 1526	4.73+00 5 1526	7.43-01 5 1526	3.64+01 5	0000	2.06+01 2 1520	0.10-02 2 1527	7.07-01 2 1527	7.14+01 2 1527	1002	1.00+00 3 1001	1.07+10 4 1520	17
0000	3.36+01 5 1520	2.09+00 5 1520	2.51+00 5 1520	1.03+00 5 1520	2.70+00 5 1520	4.24-01 5 1520	4.43+01 5	0000	2.09+01 2 1520	0.10-02 2 1527	7.07-01 2 1527	7.14+01 2 1527	1002	0.00-01 3 1001	1.07+10 5 1520	18
0.00+00 2 1007	1.74+01 5 1530	6.00-01 5 1530	7.30-01 5 1530	4.43-01 5 1530	5.01-01 5 1530	3.44-02 5 1530	1.09+01 5	0000	0000	1.03-03 4 1530	3.21-03 4 1530	2.42-01 5 1530	1002	1.00+00 3 1001	7.70+00 5 1532	19
0000	1.64+01 5 1532	1.34+00 4 1532	9.05-02 4 1532	1.30-01 4 1532	7.56-01 4 1532	2.01-02 4 1532	1.66+03 5	0000	1.60+00 4 1524	3.24-02 4 1527	6.92-01 4 1527	4.54+01 4 1527	1002	1.00+00 3 1001	0.30+00 5 1532	20
0000	0.00+00 1 1012	0000	0000	0000	0000	0000	0.00+00 1	0000	3.76-01 2 1535	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	1.00+00 3 1002	3.05+00 5 1536	21
																22
0000	0000	0000	0000	0000	0000	0000	0000	0000	7.02-01 2 1537	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	1.30+00 5 1536	23
0000	0000	0000	0000	0000	0000	0000	0000	0000	7.02-01 2 1537	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	1.30+00 5 1536	24
0000	0000	0000	0000	0000	0000	0000	0000	0000	3.45-01 2 1538	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 2 1007	1.30+00 5 1536	25
																26
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TABLE 9. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED CENTRAL APPALACHIA REGION OF COAL SUPPLY

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FOOTNOTES FOR TABLE 9

1500

THE REGION OF CENTRAL APPALACHIA INCLUDES SOUTHERN WEST VIRGINIA, VIRGINIA AND EASTERN KENTUCKY. THE AVEEAGE CALORIC CONTENT OF THE COAL DELIVERED TO ELECTRIC UTILITIES IN THIS REGION DURING THE 3RD QUARTER OF 1972 WAS 12100 BTU/LB (1212). THE AVERAGE ASH AND SULFUR CONTENTSOF UTILITY COALS IN THIS REGION ARE 11.2 PC AND 0.93 PC, RESPECTIVELY ((1053), INCLUDING THE STATE OF TENNESSEE, BUT NOT EASTERN KENTUCKY. THE AVERAGE SULFUR-CONTENT OF COAL RECEIVED AT ELECTRIC UTILITIES DURING THE 3RD QUARTER OF 1972, WAS 1.20 PC (1212)). THE DENSITY OF THE COAL IS ABOUT 85 LB/CF.

SINCE THE COAL FROM THIS REGION IS LOW IN ASH AND SULFUR, NO CLEANING IS NECESSARY FOR COAL USED FOR STEAM RAISING.

FOR THE COAL OF THIS REGION, 1.0E12 BTU IS EQUIVALENT TO APPROXIMATELY 41000 T OF COAL.

1501

SOLID WASTE PRODUCTION FROM UNDERGROUND MINES IS IN GENERAL RELATED TO THE OPENING OF THE MINE (SHAFT SINKING FOR SHAFT AND SLOPE MINES). ASSUMING AN AVERAGE MINE DEPTH OF 600 FT AND AN ADIT OF 100 SF, 3000 T OF EARTH ARE REMOVED TO SINK THE SHAFT. SIZABLE UNDERGROUND MINES HAVE AN AVERAGE PRODUCTIVE LIFE OF ABOUT 25 YRS AND PRODUCES ABOUT 2 MMT/YR (1018). HENCE, SOLID WASTE IS PRODUCED AT A RATE OF 60 T/MMT OF COAL MINED, OR 1.40 T/1.0E12 BTU IN.

1502

THE AVERAGE SEAM THICKNESS OF COAL MINED UNDERGROUND IN THIS REGION IN 1965 WAS 4.7 FT (1017). ASSUMING THIS VALUE STILL APPLIES, 4.71 AC OF LAND ARE UNDERMINED/1.0E12 BTU EQUIVALENT T IN.

OF THE ACREAGE UNDERMINED, APPROXIMATELY 25PC WILL SUBSIDE (1019). THIS SUBSIDENCE RATE IS ACTUALLY FOR ALL UNDERGROUND COAL MINES, BUT SINCE THE ROOM & PILLAR TECHNIQUE HAS BEEN PREDOMINANT IN THE US, IT IS ASSUMED THAT THIS FIGURE CHARACTERIZES THE SUBSIDENCE FOR ROOM & PILLAR MINING. EVENTUALLY ALL OF THE AREA UNDERMINED MAY SUBSIDE, BUT THE TIME SCALE IS IN EXCESS OF A CENTURY. THE 25PC SUBSIDENCE RATE IS DERIVED FROM HISTORICAL OBSERVATIONS.

SUBSIDENCE AFFECTS A SURFACE AREA GREATER THAN THE AREA UNDERMINED. THE WIDTH ON THE PERIMETER THAT IS AFFECTED BY SUBSIDENCE IS DETERMINED FROM

$$R = H \tan X$$

WHERE, R=WIDTH OF THE PERIMETER AREA AFFECTED; H=DEPTH OF MINE, AND X=ANGLE OF DRAW (ANGLE BETWEEN A VERTICAL LINE, AND A LINE CONNECTING THE FACE AND THE LIMIT OF SUBSIDENCE). THE ANGLE OF DRAW HAS BEEN CONSISTENTLY OBSERVED IN EUROPEAN COAL FIELDS TO FALL BETWEEN 35-39 DEGREES (1027,232,233). THUS, FOR AN ANGLE OF DRAW OF 37 DEGREES AND A MINE DEPTH OF 600 FT, THE WIDTH OF THE AFFECTED PERIMETER AREA IS 452 FT.

OF THE UNDERMINED AREA 1.18 AC SUBSIDES. ASSUMING A SQUARE AREA, THE SIDES ARE 227 FT IN LENGTH. HENCE, AN ADDITIONAL 9.4 AC ARE AFFECTED. THE TOTAL AREA AFFECTED BY SUBSIDENCE ENCOMPASSES 10.6 AC.

TIME AVERAGING THIS VARIABLE LAND USAGE OVER 25 YRS (FOOTNOTE 1501) THE LAND IMPACT IS 132 AC-YR/1.0E12 BTU IN.

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IN A PILE 30 FT IN HEIGHT, 4.59E-2 AC OF LAND IS OCCUPIED BY 3599
THE REFUSE PILE (FOOTNOTE 1501, SOLID WASTE PRODUCTION). FOR 3699
AN ANNUAL PRODUCTION OF 2 MMT, THE LAND IMPACT IS 5.35E-4 3799
AC-YR/1.0E12 BTU IN. 3899

1503 199

THE ACID DRAINAGE FROM ACTIVE DEEP MINES IN CENTRAL APPALACHIA 299
OCCURS AT A RATE OF 203 T OF ACIDITY/DAY, OR 4.0E-4 T/T OF 399
COAL MINED. (THE ACIDITY IS COMPUTED FROM DATA ON SUB-AREAS 499
12,14,15 AND 17-19 IN REF. (1039,5,8,9) ASSUMING THE CONTRI- 599
BUTION FROM THE DIFFERENT SOURCES ARE IN THE SAME PROPORTION 699
AS FOR ALL OF APPALACHIA. THE PRODUCTION FIGURES ARE OBTAINED 799
FROM REF.(0001).) THE SULFATE LOADING IS ABOUT TWICE AS MUCH 899
AS THE ACID LOADING (1039). 999
THE CHEMICAL COMPOSITION OF THE DRAINAGE FROM THE ACTIVE MINES 1099
ARE ESTIMATED FROM DATA ON THE MONONGAHELA RIVER BASIN (1039, 1199
133/139). THE DATA FROM 10 GAGING STATIONS WERE USED IN THE 1299
ESTIMATION AND THE COAL PRODUCTION FIGURES WERE OBTAINED FROM 1399
REF. (0001). IN DETERMINING THE HARDNESS A CONCENTRATION OF 1499
100 MG/L WERE ASSUMED TO OCCUR NATURALLY, WHILE THE METALLIC 1599
CONSTITUENTS ARE ASSUMED TO ORIGINATE FROM THE MINES. THE 1699
RELATIVE CONTRIBUTION FROM THE DIFFERENT SOURCES WAS ASSUMED 1799
TO BE THE SAME AS FOR ALL OF APPALACHIA. THE EFFLUENT 1899
BREAKDOWN IS AS FOLLOWS 1999

	T/1.0E12 BTU IN	
HARDNESS	285.0	2199
FE	5.0	2299
MN	2.1	2399
AL	0.63	2499
SO4	18.7	2599
TOTAL	331.4	2699
		2799
ACIDITY	9.35	2899
		2999

THE SEDIMENT YIELD FROM THE SOLID WASTE PILE OCCURS AT A RATE 3099
OF 2.54 T/AC-YR-IN OF RUNOFF (COMPUTED FROM DATA IN REF. 3199
1020)). THE RUNOFF IN THIS REGION AVERAGES ABOUT 20 IN., 3299
THUS, THE SEDIMENT YIELD AMOUNTS TO 2.72E-2 T/1.0E12 BTU IN 3399
(FOOTNOTE 1502, LAND USE BY REFUSE PILE). 3499

1504 199

THE OCCUPATIONAL HEALTH STATISTICS ARE OBTAINED FROM (1210,80/91 299
AND 1070) AND REPRESENT AN AVERAGE FOR 1969 AND 1970. THESE 399
FIGURES DO NOT INCLUDE INJURIES THAT RESULT DURING HAULAGE. 499

1505 199

THE EXPENSE INCURRED FOR ELECTRICAL POWER IS ESTIMATED TO BE 299
$0.17/T AT $0.01/KWH (1079). THUS, THE ENERGY REQUIREMENT 399
FOR AN UNDERGROUND MINING OPERATION (USING A CONTINUOUS MINER) 499
IS 6.97E5 KWH/1.0E12 BTU EQUIVALENT T EXTRACTED (AT 12100 BTU/ 599
LB, FOOTNOTE 1500). THE REAL ENERGY CONSUMPTION IS 7.15E9 BTU/ 699
1.0E12 BTU (3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL 799
ENERGY CONSUMPTION). ON A 1.0E12 BTU IN BASIS THE ENERGY CON- 899
SUMPTION IS 4.07E9 BTU. 999

1506 199

THE AVERAGE THICKNESS OF COAL SEAMS AUGER MINED IN THIS REGION IN 299
1965 WAS 4.2 FT (1017,7). THUS FOR EVERY 1.0E12 BTU EQUIVALENT 399
T, 5.27 AC OF SURFACE AREA ARE UNDERMINED (DENSITY IS 85 LB/CF 499
(FOOTNOTE 1500)). UNDER THE ASSUMPTION THAT THE RATIO OF LAND 599
SUBSIDED TO LAND UNDERMINED IS THE SAME AS FOR ROOM AND PILLAR 699
UNDERGROUND MINES (FOOTNOTE 1502), 1.32 AC OF SURFACE AREA 799
SUBSIDES. BECAUSE OF THE SHALLOW OVERBURDEN DEPTH, THE PERI- 899
METER EFFECT IS NEGLIGIBLE. 999
FOR AN AUGER LENGTH OF 150 FT, ABOUT 1531 FT OF WORKING BENCH 1099

ARE CREATED FOR EACH 1.0E12 BTU IN. THUS, FOR A BENCH WIDTH OF 35 FT (1052), 1.23 AC/1.0E12 BTU IN OF LAND ARE DISTURBED.

IT IS ASSUMED THAT THE EXCAVATED OVERBURDEN IS DUMPED ON THE OUTSLOPES. THUS, IN A PILE AVERAGING 15 FT IN HEIGHT THE SPOIL BANK EXTENDS 34.3 FT DOWNSLOPE FROM THE OUTCROP COVERING AN AREA OF 1.21 AC/1.0E12 BTU IN (FOOTNOTE 1507, SOLID WASTE PRODUCTION).
CALCULATIONS FROM DATA COLLECTED IN EASTERN KENTUCKY (1029, 1030,1031,1032,1033,1034) INDICATE THAT LANDS AFFECTED BY LANDSLIDES AMOUNT TO 11.4 PC OF THE OUTSLOPE COVERED BY THE SPOILS. HENCE, AN ADDITIONAL LAND ACREAGE OF 0.138 AC/1.0E12 BTU IN IS DAMAGED.
THE TOTAL LAND DAMAGED DURING AUGERING AMOUNTS TO 3.90 AC/ 1.0E12 BTU IN. THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS 48.8 AC-YR/1.0E12 BTU IN.

1507

ASSUMING A TOPOGRAPHIC SLOPE OF 40 DEGREES (ON SLOPES LESS STEEP IT IS MORE THAN LIKELY THAT CONTOUR STRIPPING WILL BE EMPLOYED. AUGERING MAY THEN FOLLOW AFTER THE ECONOMIC STRIPPING LIMIT IS REACHED.), 39300 T OF SOLID WASTE ARE PRODUCED FOR EVERY 1.0E12 BTU EQUIVALENT T (BENCH WIDTH OF 35 FT AND LENGTH OF 1531 FT, FOOTNOTE 1506).

1508

DIESEL FUEL CONSUMPTION AMOUNTS TO 6220 GAL/1.0E12 BTU IN (FOOTNOTE 1010). THE AIR EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7) ASSUMING THE CHARACTERISTICS OF A DIESEL TRUCK ENGINE.

1509

THE COMPOSITION OF THE DRAINAGE FROM AUGER MINES IS ASSUMED TO BE THE SAME AS FOR CONTOUR MINES (FOOTNOTE 1514) EXCEPT FOR THE DIFFERENCE IN PRIMARY EFFICIENCIES. THE SEDIMENT YIELD OCCURS AT A RATE OF 2.54 T/AC-YR-IN. OF RUNOFF. THE AVERAGE RUNOFF FOR THIS REGION IS ABOUT 20 IN, THUS, THE SEDIMENT YIELD IS 859 T/1.0E12 BTU IN (FOOTNOTE 1506).

1510

THE AVERAGE SLOPE ANGLE FOR THIS REGION IS ABOUT 28 DEGREES ((1028,51), USING THE DATA FOR THE ECONOMIC AREAS 50,51,52 AND 53). ASSUMING A BENCH WIDTH OF 150 FT AND A 15 FT RIM OF BLOSSOM COAL, 5.50E5 T OF EARTH ARE MOVED PER 1.0E12 BTU COAL IN THE GROUND.
AS A REQUIREMENT OF BACKFILLING, IT IS ASSUMED THAT 4 FT OF MATERIAL, ABOVE THE HEIGHT OF THE COAL SEAM, MUST BE REPLACED. THUS, FOR A 4.2 FT SEAM THICKNESS 4.59E04 T OF SPOILS/1.0E12 BTU ARE REPLACED FOR BACKFILLING THE BENCH.
THE SOLID WASTE PRODUCTION IS THEREFORE 5.04E5 T/1.0E12 BTU IN.

1511

FOR A COAL SEAM THICKNESS OF 4.2 FT (1017) AND A COAL DENSITY OF 85 LB/CF, 5.27 AC OF LAND IS OVERTURNED PER 1.0E12 BTU IN.

ON SLOPES GREATER THAN 15 DEGREES,TECHNIQUES OF CONTOUR STRIPPING ARE EMPLOYED. IT IS ASSUMED THAT THE CONVENTIONAL CONTOUR MINING IS USED. EXCEPT FOR THE MATERIAL USED TO BACKFILL THE BENCH, ALL OF THE OVERBURDEN IS DEPOSITED ON THE OUTSLOPE AND ASSUMED TO REST AT THE ANGLE OF REPOSE (ABOUT 37 DEGREES). IT IS ALSO ASSUMED THAT A 15 FT RIM OF BLOSSOM COAL IS LEFT IN PLACE. THE MEAN SLOPE ANGLE AND THE BENCH WIDTH ARE ASSUMED TO BE 28 DEGREES (1028,51) AND 150 FT RESPECTIVELY (THE 28 DEGREE SLOPE ANGLE IS THE AVERAGE FOR SLOPES GREATER THAN 15 DEGREES IN CENTRAL APPALACHIA). HENCE, A HIGHWALL OF 87.8 FT IS CREATED AND TO MINE THE REQUIRED TONNAGE OF COAL 1531 FT OF

HIGHWALL (BENCH LENGTH) ARE GENERATED. THUS, FOR A SPOIL BANK WITH A MEAN HEIGHT OF 30 FT, THE PILE REACHES 219 FT DOWNSLOPE FROM THE OUTCROP AND ENCOMPASSES AN AREA OF 7.71 AC/1.0E12 BTU IN (FOOTNOTE 1510, SOLID WASTE PRODUCTION).

THE DRAINAGE DITCH ABOVE THE HIGHWALL IS ASSUMED TO AFFECT 50 FT UPSLOPE. HENCE, AN ADDITIONAL 1.76 AC/1.0E12 BTU IN IS AFFECTED.

CALCULATIONS FROM DATA COLLECTED IN EASTERN KENTUCKY (1029, 1030,1031,1032,1033,1034) INDICATE THAT LAND AFFECTED BY LANDSLIDES AMOUNT TO 11.4 PC OF THE OUTSLOPE AREA COVERED BY THE SPOILS. THUS, AN ADDITIONAL LAND ACREAGE OF 0.879 AC/ 1.0E12 BTU IN IS DAMAGED. (IT IS RECOGNIZED THAT THIS WILL NOT BE THE CASE FOR ALL MINES. SOME STATES REQUIRE PRACTICES THAT MINIMIZE THE OCCURRENCE OF LANDSLIDES. OBSERVATIONS INDICATE THAT THE OCCURRENCE OF LANDSLIDES IS SIGNIFICANTLY REDUCED WHEN THE SPOIL PILES ARE STABILIZED.)

ALTHOUGH RECLAMATION PRACTICES ARE EMPLOYED, NOT ALL STATES HAVE MANDATORY VEGETAL SURVIVAL RATE REQUIREMENTS (1028) NOR ARE THERE STIPULATIONS FOR RECLAMATION OF TOP SOIL. THUS, EXCEPT FOR COVERING THE EXPOSED SEAM AND THE PIT FLOOR NO RECLAMATION IS ASSUMED.

THE TOTAL LAND USAGE IS 15.6 AC/1.0E12 BTU IN. THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS THEREFORE 195 AC-YR/1.0E12 BTU IN.

1512

BY LINEARLY INTERPOLATING THE DATA IN REF. (1041,12,23), AND ASSUMING THE OILS TO BE DIESEL FUEL COSTING $0.20/GAL AND THE COST OF POWER TO BE $0.015/KWH THE TOTAL ENERGY CONSUMPTION FOR A 2 MMT/YR CONTOUR STRIPPING OPERATION IS ABOUT 1.33E10 BTU FOR EVERY 1.0E12 BTU EQUIVALENT T EXTRACTED. THE TOTAL IS COMPOSED OF 1.82E9 BTU OF FUEL AND 1.13E6 KWH OF ELECTRICAL ENERGY. THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL POWER USAGE TO THE FUEL CONSUMPTION. ON A 1.0E12 BTU IN BASIS THE TOTAL IS 1.06E10 BTU.

1513

DIESEL FUEL CONSUMPTION AMOUNTS TO 10500 GAL/1.0E12 BTU IN (FOOTNOTE 1512). THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7) USING THE CHARACTERISTICS FOR A DIESEL TRUCK ENGINE. SINCE ADEQUATE MOISTURE IS AVAILABLE IN THIS REGION, FUGITIVE DUST IS NOT EXPECTED TO BE A SERIOUS PROBLEM.

1514

THE ACID DRAINAGE FROM ACTIVE SURFACE MINES IN CENTRAL APPALACHIA OCCURS AT A RATE OF 11 T OF ACIDITY/DAY, OR 1.0E-4 T/T OF COAL MINED (1039,5,8,9, SEE ALSO FOOTNOTE 1503). THE SULFATE LOADING IS ABOUT TWICE THE ACID LOADING (1039). THE CHEMICAL COMPOSITION OF THE DRAINAGE WAS DETERMINED FROM DATA ON THE MONONGAHELA RIVER BASIN (FOOTNOTE 1404). THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	T/1.0E12 BTU IN
HARDNESS	29.5
FE	0.518
MN	0.219
AL	0.0650
SO4	6.56
TOTAL	36.9
ACIDITY	3.28

THE SEDIMENT IS YIELDED AT A RATE OF 2.54 T/AC-YR-IN. OF RUNOFF. THE AVERAGE RUNOFF FOR THIS REGION IS ABOUT 20 IN.

THUS, THE SEDIMENT YIELD IS 5450 T/1.0E12 BTU IN (FOOTNOTE 1511, LAND USE BY SPOIL BANK).

1515

THE AVERAGE DISTANCE FROM MINE TO TIPPLE IN THIS REGION IS 4.7 MI. (0001,344) AND DATA FROM STUDIES CONDUCTED IN EASTERN KENTUCKY (1024,1031,1032,1033,1034) INDICATE A MEAN HAULAGE ROAD RIGHT-OF-WAY OF 53 FT (6.4 AC/MI). THUS, THE HAULAGE ROAD OCCUPIES 30.1 AC. ASSUMING AN ANNUAL PRODUCTION FROM THE MINE OF 2 MMT (FOOTNOTE 1405), 2.1 PC OF THE ROAD USAGE IS ATTRIBUTED TO THE TRANSPORT OF 1.0E12 BTU EQUIVALENT T. THE LAND IMPACT IS, THEREFORE 0.632 AC-YR/1.0E12 BTU.

1516

THE SEDIMENT YIELD FROM COAL HAULAGE ROADS OCCURS AT A RATE OF 35 T/AC-YR (FOOTNOTE 1416). THUS, 22.2 T/1.0E12 BTU OF SEDIMENT IS YIELDED (FOOTNOTE 1515, LAND USE BY THE HAULAGE ROAD).

1517

IN 1969 THE AVERAGE TRUCK CAPACITY FOR THIS REGION WAS 24 T AND THE AVERAGE HAULAGE DISTANCE FROM MINE TO TIPPLE WAS 4.7 MI (0001,344). THE FUEL CONSUMPTION RATE IS ASSUMED TO BE 7 GAL/1000 TMI (0002,3-7). ASSUMING A GROSS TO TARE WEIGHT RATIO OF 2.5 TO 1 FOR THE TRUCKS, A ROUND TRIP IS 263 TMI. SINCE 1710 ROUND TRIPS ARE REQUIRED TO HAUL 1.0E12 BTU EQUIVALENT T, 3160 GAL OF DIESEL FUEL IS CONSUMED. THE EMISSIONS BREAKDOWN FOR A DIESEL POWERED TRUCK IS GIVEN IN REF. (0002,3-7).
DUSTING FROM HAULAGE ROADS ARE CONTROLED BY WATERING DOWN, OILING OR SOME OTHER METHOD.

1518

FUEL CONSUMPTION BY THE HAULAGE TRUCKS AMOUNTS TO 3160 GAL/1.0E12 BTU (FOOTNOTE 1517). THUS, THE ENERGY CONSUMPTION IS 4.38E8 BTU.

1519

THE CONVEYOR SYSTEM CONSUMES 1.03E6 KWH/YR OR ABOUT 21300 KWH/1.0E12 BTU (FOOTNOTE 1049). THE REAL ENERGY CONSUMPTION (2.18E8 BTU) IS 3 TIMES THE ELECTRICAL ENERGY CONSUMPTION.

1520

A CRUSHER OPERATING AT 275 T/HR AND CRUSHING TO A TOPSIZE OF 1.5 IN. REQUIRES A 140 HP MOTOR (1014,7-14). THUS, 1.56E4 KWH OF ENERGY ARE UTILIZED TO CRUSH 1.0E12 BTU EQUIVALENT T OF COAL. THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY UTILIZATION.

1521

IT IS ASSUMED THAT 0.006 PC OF THE FEED TO THE PREPARATION PLANT IS REMOVED AS TRAMP IRON. HENCE, 2.46 T OF TRAMP IRON IS COLLECTED FOR EVERY 1.0E12 BTU EQUIVALENT T PROCESSED. THE PERCENTAGE OF TRAMP IRON IS ESTIMATED FROM INFORMATION IN REF. (1059,6-31) ASSUMING THAT THE LARGE PLANT PROCESSED 1000 T/HR.

1522

ENERGY CONSUMPTION AT A CRUSHING AND SIZING PLANT IS ABOUT 1.68E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION,1.46E5 KWH ARE ELECTRICITY AND 2.36E8 BTU ARE OIL (1064, 12A-16,39, ASSUMING ALL FUEL PURCHASED TO BE OIL AT A COST OF $0.20/GAL). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL CONSUMPTION TO THE OIL USAGE.

1523

APPROXIMATELY 35 AC OF LAND ARE UTILIZED FOR THE CRUSHING AND SIZING PLANT AND A 10000 T UNIT TRAIN LOADING FACILITY (1021). THUS, THE LAND IMPACT IS 0.724 AC-YR/1.0E12 BTU.
IT IS ASSUMED THAT THE THE MODES OF TRANSPORT OTHER THAN UNIT TRAINS HAVE SIMILAR LAND REQUIREMENTS.

1524

IN A STUDY OF UNIT TRAINS CONDUCTED BY THE BUR OF MINES (1006) THE AVERAGE HAULAGE DISTANCE FOR MINES IN THIS REGION WAS 395 MI. THIS FIGURE IS USED FOR THIS ANALYSIS. ENERGY CONSUMPTION BY FREIGHT TRAINS, ASSUMED TO APPLY AS WELL TO UNIT TRAINS, IS 690 BTU/TMI (FOOTNOTE 7013), OR 0.005 GAL OF DIESEL FUEL/TMI (5.825E6 BTU/BBL). FROM DATA IN (0021,31) THE ENERGY CONSUMPTION ASSUMES AN AVERAGE OF 3 LOCOMOTIVES PER TRAIN. THE GROSS TO TARE WEIGHT RATIO OF THE CAR IS 4 TO 1 AND THE UNIT TRAIN CARRIES 10000 TON/TRIP (FOOTNOTE 1005). HENCE, THE HAULAGE FOR EACH ROUND TRIP IS 6.59E6 TMI AND 1.35E5 GAL OF FUEL IS CONSUMED TO TRANSPORT 1.0E12 BTU EQUIVALENT T. THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7)

WINDAGE LOSSES AMOUNT TO .04 PC OF THE TONNAGE HAULED AND ARE ACCOUNTED FOR PRIMARILY DURING HANDLING AT EITHER END POINT. THUS, 16.4 T OF PARTICULATES ARE RELEASED/1.0E12 BTU.

1525

DIESEL FUEL CONSUMPTION AMOUNTS TO 1.35E5 GAL/1.0E12 BTU (FOOTNOTE 1524). THUS, THE ENERGY CONSUMPTION IS 1.87E10 BTU.

1526

THE TOTAL MILES OF RAILROAD OPERATED IN THE EASTERN DISTRICT (DIVISION MADE BY ICC, (0033,II)) IS 54000 MI (0033,59). THUS, FOR A RIGHT-OF-WAY OF 6 AC/MI (FOOTNOTE 1027) THE TOTAL LAND USAGE IS 324,000 AC.

OF THE TOTAL TONNAGE OF FREIGHT HAULED IN 1971, COAL ACCOUNTED FOR 43 PC, OR 214E6 TONS, OF WHICH 53.8 PC, OR 115E6 TONS, ORIGINATED FROM THIS REGION (0039,27 AND 1004,52,53). HENCE, 26.6 AC-YR/1.0E12 BTU IS ATTRIBUTED TO THE HAULAGE OF COAL FROM THIS REGION.

1527

IN THE EASTERN DISTRICT (0033,II) RAILWAY ACCIDENTS CLAIMED 705 LIVES, INJURED 9304 PERSONS (0006,17,54) AND AN AVERAGE OF 93 MAN-DAYS WERE LOST PER INJURY (0006,4).

OF THE TOTAL KILLED AND INJURED, 0.0618 FATALITIES AND 0.767 NON-FATAL INJURIES ARE ATTRIBUTED TO THE TRANSPORT OF 1.0E12 BTU EQUIVALENT T FROM THIS REGION. FOR THE SAME HAULAGE 71.4 MAN-DAYS ARE LOST. (FOOTNOTE 1526, COAL TRANSPORTED).

1528

THE AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 275 MI, WHICH IS THE APPROXIMATE DISTANCE FROM THE COAL FIELDS OF THIS REGION TO ALEXANDRIA AND NORFOLK, VA., AND ATLANTA, GEORGIA. FUEL CONSUMPTION IS 0.005 GAL/TMI (FOOTNOTE 1524). ASSUMING 1000 T OF COAL ARE SHIPPED PER TRAIN, ACCOUNTING FOR 20 PC OF THE TOTAL TONNAGE OF ANY ONE SHIPMENT, A GROSS TO TARE WEIGHT RATIO OF 4/1 AND ONLY ONE WAY DIESEL FUEL CONSUMPTION ATTRIBUTED TO COAL, 77100 GAL OF DIESEL FUEL CONSUMPTION ARE ATTRIBUTED TO THE HAULAGE OF 1.0E12 BTU EQUIVALENT T OF COAL. THE EMISSION FACTORS ARE COMPUTED FROM INFORMATION ON DIESEL LOCOMOTIVES IN (0002,3-7).

THE WINDAGE LOSSES ARE ASSUMED TO BE APPROXIMATELY .08 PC OF THE TOTAL SHIPMENT. HENCE, ABOUT 32.8 T OF PARTICULATES ARE RELEASED TO THE ATMOSPHERE/1.0E12 BTU. (MOST OF THESE LOSSES OCCUR DURING HANDLING AT EITHER END POINT.)

1529

DIESEL FUEL CONSUMPTION AMOUNTS TO 77100 GAL/1.0E12 BTU (FOOTNOTE 1528). THUS, THE ENERGY CONSUMPTION IS 1.07E10 BTU.

1530

THE AVERAGE CAPACITY OF A BARGE IS 25000 T (1005,34), AND THE AVERAGE HAULAGE DISTANCE IS ASSUMED TO BE 300 MI (THE APPROXIMATE DISTANCE TO CINCINNATI, OHIO OR PITTSBURGH, PA., VIA THE KANAWHA AND OHIO RIVERS). THE EMISSION FACTORS ARE COMPUTED FROM DATA ON MOTORSHIPS UNDERWAY IN (0002,3-11).
THE WINDAGE LOSSES (OCCURING MAINLY DURING HANDLING AT THE END POINTS) ARE ASSUMED TO BE .04 PC OF THE TOTAL SHIPMENT AS IN THE CASE FOR UNIT TRAINS. THUS, 16.4 T OF COAL FINES ARE EMITTED AS PARTICULATES/1.0E12 BTU.

1531

A BARGE CONSUMES 378 BTU/TMI (FOOTNOTE 7001). THUS, FOR AN AVERAGE HAULAGE DISTANCE OF 300 MI (FOOTNOTE 1530), A BARGE CAPACITY OF 25000 T AND ASSUMING A GROSS TO TARE WEIGHT RATIO OF 4 TO 1, THE ENERGY CONSUMPTION IS 7.76E9 BTU FOR EACH 1.0E12 BTU EQUIVALENT T OF COAL TRANSPORTED.

1532

WHEN TRUCKS ARE UTILIZED IT IS USUALLY FOR SHORT HAULAGE DISTANCES THAT AVERAGE ABOUT 10 MI (1013). ASSUMING AN AVERAGE TRUCK CAPACITY OF 20 T, A GROSS TO NET WEIGHT RATIO OF 2.5 TO 1, AND A FUEL CONSUMPTION RATE OF 7 GAL/1000 TMI, 6700 GAL OF DIESEL FUEL ARE CONSUMED. THE EMISSIONS FROM A DIESEL ENGINE ARE GIVEN IN (0002,3-7).
IT IS ASSUMED THAT .04 PC OF THE TOTAL SHIPMENT IS LOST DUE TO WINDAGE AND HANDLING AT EITHER END POINT (FOOTNOTE 1524). THE AMOUNT RELEASED AS PARTICULATES IS THEREFORE 16.4/1.0E12 BTU.

1533

DIESEL FUEL CONSUMPTION AMOUNTS TO 6700 GAL/1.0E12 BTU. THUS, THE ENERGY CONSUMPTION IS 9.30E8 BTU (FOOTNOTE 1532).

1534

THE LAND USE BY DIESEL TRUCKS IS 1.67E-6 AC/TMI (FOOTNOTE 7026). THUS, THE LAND LAND IMPACT ATTRIBUTED TO THE HAULAGE OF THE COAL BY TRUCK IS 1.60 AC-YR/1.0E12 BTU (FOOTNOTE 1532).

1535

IT IS ASSUMED THAT THE AVERAGE CONVEYOR LENGTH IS 5 MI (FOOTNOTE 1335). HENCE, FOR A RIGHT-OF-WAY OF 30 FT, 18.2 AC OF LAND IS OCCUPIED. THE SYSTEM TRANSPORTS 2 MMT/YR. THEREFORE IN TERMS OF ENERGY, 0.376 AC-YR/1.0E12 BTU OF LAND IS IMPACTED.

1536

ELECTRICAL ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYERS IS 3.56E4 KWH/1.0E12 BTU (FOOTNOTE 1053). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF ELECTRICAL ENERGY CONSUMPTION.

1537

STORAGE OF THE COAL IN A PILE AVERAGING 30 FT IN HEIGHT REQUIRES THE USE OF 0.762 AC-YR/1.0E12 BTU.
IT IS ASSUMED THAT UNDERGROUND STORAGE ALSO HAS THE SAME LAND REQUIREMENTS.

1538

GENERALLY, SILOS HAVE A DIAMETER OF 70 FT AND ARE ABOUT 150 FT IN HEIGHT. THE STORAGE CAPACITY IS APPROXIMATEY 11000 T (1006). THUS, 4 SILOS ARE REQUIRED FOR STORING 1.0E12 BTU EQUIVALENT T. THE LAND IMPACTED BY THE SILOS IS THEREFORE 0.345 AC-YR/1.0E12 BTU.

1539

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYORS FOR STORAGE AMOUNTS TO 1.51E4 KWH/1.0E12 BTU (FOOTNOTES 1058,1059, 1060). THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMED.

		CONTROLLED FUEL: COAL	CONTROLLED REGION: CENTRAL APPALACHIA	1	2	3	4	5	6	7	8	9	10	11	12	13	14
				WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL. 12)													
						DISSOLVED SOLIDS											
ROW	ABBREVIATION	ACTIVITY PROCESS		ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12}BTU	PARTIC-ULATES	NO_x
1	EXTRC	EXTRACTION															
2	UNDRG	UNDERGROUND															
3	ROOMP	ROOM & PILLAR		0.00+00 1 1552	4.80+01 4 1552	0000	0000	1.63+01 3 1552	1.63+01 4	2.43+01 2 1552	0000	1.65+01 4	0000	0.00+00 1 0007	0000	0.00+00 1 1014	0.00+00 1 [illegible]
4	AUGER	AUGER		0.02+00 1 1554	3.30+01 3 1554	0000	0000	5.23+00 4 1554	5.23+00 4	7.15+01 2 1554	0000	5.24+00 4	0000	0.00+00 1 0007	0000	4.94-02 5 1500	7.15+00 5 [illegible]
5	SURFC	SURFACE															
6	STRP>	>10° SLOPE		4.20+00 1 1554	5.49-01 3 1554	0000	0000	8.92+00 4 1554	8.92+00 4	2.00+1 2 1554	0000	9.12+00 4	0000	0.00+00 1 0007	0000	6.83-02 5 1513	1.94+00 5 [illegible]
7	TRNSP	TRANSPORTATION															
8	TRUCK	TRUCK		0000	0000	0000	0000	0000	0000	0.00+00 2 1501	0000	0.00+00 3	0000	0000	0000	3.05-02 5 1517	5.83-01 6 [illegible]
9	CONVY	CONVEYOR		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1012	0.00+00 1 [illegible]
10	MINRA	MINE RAIL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1042	0.00+00 1 [illegible]
11	PROCS	PROCESSING															
12	BRKPR	PRIMARY BREAKING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	[illegible]
13	RCLEN	ROUGH CLEANING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	[illegible]
14	RWSIZ	RAW COAL SIZING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	[illegible]
15	BRKSZ	BREAKING & SIZING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 1060	[illegible]
16	DISTB	DISTRIBUTION															
17	UNITT	UNIT TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	5.00+00 2 1077	[illegible]
18	MIXT	MIXED TRAIN		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.01-01 5 1520	3.06+00 5 [illegible]
19	BARGE	RIVER BARGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.38+01 5 1520	7.82-00 5 [illegible]
20	TRUCK	TRUCKING		0000	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	1.74-01 5 1520	6.59-01 5 [illegible]
21	CONVY	CONVEYORS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.64-01 5 1520	1.24+00 6 [illegible]
22	STORA	STORAGE															
23	ABGRD	ABOVE GROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 [illegible]	[illegible]
24	UGRND	UNDERGROUND		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	[illegible]
25	SILOS	SILOS OR BINS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0000	[illegible]
26																	
27																	
28																	
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ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1500 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS
OF CENTRAL APPALACHIAN COAL AND REGIONAL DESCRIPTION.

12		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	ROW
		AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
	THERMAL (BTU/10^{12} BTU)	PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/10^{12} BTU	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	
																	1
																	2
0.0007	0000	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1 1014	0.00+00 1	2.48+03 3 1500	1.13+02 3 1553	1.34-02 1 1504	5.44-01 1 1504	1.90+01 1 1504	1070	1.70-01 1 1002	4.10+00 5 1551	3
0.0007	0000	4.04-02 5 1508	1.15+00 5 1508	2.40-02 5 1508	1.15-01 5 1508	7.00-01 5 1508	1.87-02 5 1508	2.11+00 5	1.94+04 2 1555	2.38+01 3 1558	1.02+03 3 1504	9.41-02 3 1504	1.80+00 3 1504	1000	4.90-01 1 1002	2.26+00 5 1553	4
											1.78-03 1 1504	1.64-01 1 1504	3.10+00 1 1504				5
0.0007	0000	6.83-02 5 1513	1.94+00 5 1513	1.42-01 5 1513	1.96-01 5 1513	1.16+00 5 1513	3.15-02 5 1513	3.56+00 5	1.00+04 4 1558	2.48+01 4 1558	0000	0000	0000	1001	8.00-01 1 1003	1.07+10 5 1560	6
											3.18-03 2 1451	1.46-01 2 1451	4.00-02 2 1451				7
0000	0000	2.05-02 5 1517	9.40-01 4 1517	4.38-02 4 1517	5.60-02 4 1517	3.30-01 4 1517	9.30-03 4 1517	1.07+00 5	0000	7.30+01 3 1067	0000	0000	0000	1001	1.00+00 1 1000	4.30+00 3 1310	8
0000	0000	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1 1012	0.00+00 1	0000	0.00+00 1 1012	0000	0000	0000	1002	1.00+00 1 1000	2.10+00 4 1010	9
0000	0000	0.00+00 1 1043	0.00+00 1 1043	0.00+00 1 1043	0.00+00 1 1043	0.00+00 1 1043	0.00+00 1 1043	0.00+00 1	0000	0.00+00 1 1043	0000	0000	0000	1002	1.00+00 1 1000	0000	10
											3.02-04 1 1453	2.27-02 1 1453	7.00-01 1 1453				11
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1002	1.00+00 1 1007	1.00+00 3 1530	12
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	2.00+00 4 1521	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	13
0000	0000	0.00+00 2 1000	0000	0000	0000	0000	0000	0.00+00 2	0000	0000	0000	0000	0000	1002	1.00+00 1 1007	0000	14
0000	0000	0.00+00 1 1077	0000	0000	0000	0000	0000	0000	2.00+00 4 1521	7.24-01 3 1523	0000	0000	0000	1002	1.00+00 1 1000	1.00+00 4 1525	15
																	16
0000	0000	1.61-01 5 1524	5.06-00 5 1524	4.10+00 5 1524	3.16+00 5 1524	4.73+00 5 1524	5.43-01 5 1524	3.64-01 5	0000	2.00+01 2 1526	6.10-02 2 1527	7.07-01 2 1527	7.16+01 2 1527	1002	1.00+00 3 1001	1.07+10 4 1528	17
0000	0000	3.58-01 5 1528	2.80-00 5 1528	2.51+00 5 1528	1.93+00 5 1528	2.70+00 5 1528	4.24-01 5 1528	4.45-01 5	0000	2.00+01 2 1526	6.10-02 2 1527	7.07-01 2 1527	7.16+01 2 1527	1002	9.90-01 3 1001	1.07+10 5 1528	18
0.0007	0.00+00 2 0007	1.74-01 5 1530	6.60-01 5 1530	7.38-01 5 1530	4.43-01 5 1530	8.83-01 5 1530	3.44-02 5 1530	1.00+01 5	0000	0000	1.03-03 4 1329	3.31-03 4 1329	2.63-01 5 1329	1003	1.00+00 5 1001	7.70+00 5 1530	19
0000	0000	1.64-01 5 1532	1.26+00 4 1532	9.05-02 4 1532	1.20-01 4 1532	7.54-01 4 1532	2.01-02 4 1532	1.86-01 5	0000	1.00+00 6 1534	3.24-02 4 1327	5.92-01 4 1327	4.54+01 4 1327	1002	1.00+00 3 1001	9.30+00 5 1532	20
0000	0000	0.00+00 1 1013	0000	0000	0000	0000	0000	0.00+00 1	0000	3.79-01 3 1533	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1002	1.00+00 3 1003	3.05+00 5 1536	21
																	22
0.0007	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.02-01 2 1537	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1002	9.00-01 2 1007	1.10+00 5 1536	23
0.0007	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.02-01 2 1537	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1002	8.00-01 2 1007	1.10+00 5 1536	24
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.49-01 2 1539	0.00+00 1 0997	0.00+00 1 0997	0.00+00 1 0997	1002	9.93-01 2 1007	1.10+00 5 1536	25
																	26
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TABLE 10. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED CENTRAL APPALACHIA REGION OF COAL SUPPLY

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FOOTNOTES FOR TABLE 10

1550

A HYDRATED LIME PROCESS IS UTILIZED FOR TREATMENT OF THE ACID DRAINAGE FROM UNDERGROUND MINES. ASSUMING AN ACID LOAD OF 1000 PPM THE PLANT WILL HAVE TO PROCESS ABOUT 0.8 MMG/DAY (FOOTNOTE 1503 MINE DRAINAGE POLLUTANT LOADS). THE TOTAL IRON CONCENTRATION IS ABOUT 85 PPM. THUS, THE SOLID WASTE PRODUCTION IS ABOUT 13.7 AC-FT/YR (1102,233). ASSUMING A PRECIPITATE DENSITY OF 71 LB/CF (1114,288) SOLID WASTE IS GENERATED AT A RATE OF 21200 T/YR, OR 248 T/1.0E12 BTU IN. THIS IS IN ADDITION TO THE REFUSE PRODUCED FROM THE MINING OPERATION-1.40 T/1.0E12 BTU IN (FOOTNOTE 1501).

1551

THE AVERAGE ANNUAL POWER EXPENSES FOR A HYDRATED LIME SYSTEM UTILIZED IN OPERATION YELLOWBOY WAS ABOUT $16400/MMGAL/D (1102,231). THUS, AT A COST OF $0.015/KWH, THE ENERGY REQUIREMENT TO OPERATE THE 0.8 MMGAL/D TREATMENT PLANT IS 8.75E5 KWH/YR, OR 1.81E4 KWH/1.0E12 BTU. THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMED. ON A 1.0E12 BTU IN BASIS THE TOTAL ENERGY CONSUMPTION IS 1.05E8 BTU. THIS ENERGY USE IS IN ADDITION TO THE ENERGY EXPENDED FOR THE MINING OPERATION, I.E., 4.07E9 BTU (FOOTNOTE 1505).

1552

IT IS ASSUMED THAT THE FINAL DISCHARGE WILL BE IN COMPLIANCE WITH THE GUIDELINES ESTABLISHED BY EPA (1112). IN LIME TREATMENT, BECAUSE OF THE SOLUBILITY OF CALCIUM SULFATE, THE HARDNESS OF THE WATER WILL INCREASE (1113,24). MOST OF THE METALLIC SALTS WILL PRECIPITATE AS THE PH OF THE SOLUTION IS RAISED. THE EFFLUENT BREAKDOWN IS AS FOLLOWS

	PPM	T/1.0E12 BTU IN
SUSPENDED SOLIDS	30	0.243
ACIDITY	0	0.00
ALKALINITY	60	0.486
IRON	4	0.032
MN	4	0.032
AL	1	0.008
$CASO_4$	2000	16.2
SUBTOTAL		16.3

THE ALKALINITY CONCENTRATION IS OBTAINED FROM DATA IN REF. (1103), THE MN AND AL FROM SOLUBILITY CURVES, WHILE THE REMAINDER ARE IN COMPLIANCE WITH THE EPA GUIDELINES. THE VOLUME OF THE DISCHARGE IS ABOUT 85 PC OF THE INFLOW VOLUME (1103), I.E., 0.68 MMGAL/DAY AND THE FACILITY OPERATES 245 D/YR.

1553

IT IS ASSUMED THAT THE TREATMENT FACILITY REQUIRES A 2 MMGAL RAW WATER STORAGE POND AND A 80 MMGAL SETTLING POND. THE LAND IS ASSUMED AVAILABLE. FOR A DEPTH OF 20 FT FOR BOTH PONDS, 12.5 AC OF SURFACE AREA ARE REQUIRED. THE TREATMENT PLANT OCCUPIES ABOUT 3 AC (1114). THUS, THE TOTAL LAND IMPACT IS 0.181 AC-YR/1.0E12 BTU IN.
THIS IS IN ADDITION TO THE LAND IMPACTED DURING MINING, I.E., 132 AC-YR/1.0E12 BTU IN (FOOTNOTE 1502).

1554

BECAUSE OF THE RELATIVELY LOW ACIDITY CONCENTRATION AND FLOW RATE, A SODA ASH FACILITY IS UTILIZED TO NEUTRALIZE THE ACID DRAINAGE. SODIUM BASED ALKALIS EFFECTIVELY REMOVE ACIDITY. IRON,

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ALUMINUM AND OTHER OXIDES, BUT WILL NOT REMOVE THE SULFATES 599
AS SODIUM SULFATE IS A HIGHLY SOLUBLE SALT (1102,130). 699
THE FACILITY TREATS A DRAINAGE OF 0.4 MMGAL/D WITH AN ACIDITY 799
CONCENTRATION OF 500 PPM, IRON CONCENTRATION OF 85 PPM AND 899
SULFATE LOAD OF 8.2 T/1.0E12 BTU OUT (FOOTNOTE 1514, POLLUTANT 999
LOAD). THUS, THE EFFLUENT BREAKDOWN IS AS FOLLOWS 1099

	PPM	T/1.0E12 BTU IN AUGER	CONTOUR	
				1199
SUSPENDED SOLIDS	30	0.115	0.200	1299
ACIDITY	0	0.00	0.00	1399
ALKALINITY	88	0.339	0.589	1499
				1599
IRON	0.9	0.0035	0.0060	1699
MN	1.5	0.0058	0.0100	1799
AL	0.5	0.0019	0.0033	1899
SO_4		3.77	6.56	1999
NA		1.34	2.34	2099
SUBTOTAL		5.12	8.92	2199
				2299
				2399

THE SUSPENDED SOLIDS, ACIDITY AND IRON ARE IN COMPLIANCE 2499
WITH THE GUIDELINES ESTABLISHED BY EPA (1112), WHILE THE 2599
CONCENTRATION OF THE OTHERS ARE BASED ON THE RESULTS OF AN 2699
ACTUAL OPERATION (1106). 2799

1555 199

THE SLUDGE PRODUCED FROM THE SODA ASH TREATMENT PROCESS IS ABOUT 299
4 PC BY VOLUME (1106). THUS, FOR THE TREATMENT OF 0.4 MMGAL/D 399
AND AN ASSUMED SLUDGE DENSITY OF 0.03 T/CF, SOLID WASTE IS 499
GENERATED AT A RATE OF 148 T/1.0E12 BTU IN. 599
THIS IS IN ADDITION TO THE SOLID WASTE PRODUCED DURING THE 699
AUGERING OPERATION, I.E., 3.93E4 T/1.0E12 BTU IN (FOOTNOTE 799
1507). 899

1556 199

DURING AUGER MINING A TOTAL OF 2.58 AC/1.0E12 BTU IN OF LAND ARE 299
COVERED BY THE BENCH AND SPOIL PILE AND 1.32 AC/1.0E12 BTU IN 399
ARE AFFECTED BY SUBSIDENCE (FOOTNOTE 1506). 499
IN TIME AVERAGING THE LAND IMPACT,THE EFFECTS OF RECLAMATION 599
MUST BE CONSIDERED. RECLAMATION IN THIS CASE REQUIRES THE 699
RESTORATION OF THE LAND TO THE ORIGINAL CONTOUR (OR AS CLOSE 799
TO THE ORIGINAL CONTOUR AS POSSIBLE), AND STABILIZING THE 899
SURFACE AGAINST EROSION. MINIMIZING EROSION INVOLVES BENEFI- 999
CIAL GRADING (TERRACING, GOUGING, ETC.) AND ESTABLISHING AN 1099
HERBACEOUS COVER. IN APPALACHIA ABOUT 3 GROWING SEASONS ARE 1199
REQUIRED TO ESTABLISH A 95 PC COVER OF GRASS AND LEGUMES 1299
(1101). 1399
USING THE 3 YR CRITERION THE TIME AVERAGED LAND IMPACT IS 1499
7.28 AC-YR/1.0E12 BTU IN FOR THE BENCH AND SPOIL PILE AND 1599
16.5 AC-YR/1.0E12 BTU FOR THE SUBSIDED AREA. 1699
IT IS ASSUMED THAT A 20 MMGAL SETTLING BASIN IS REQUIRED FOR 1799
THE TREATMENT FACILITY. THE LAND IS ASSUMED AVAILABLE. FOR 1899
A DEPTH OF 10 FT, 6.1 AC OF LAND ARE NEEDED. THE FACILITY 1999
ITSELF REQUIRES VERY LITTLE LAND (1106). HENCE, AN ADDITIONAL 2099
0.058 AC-YR/1.0E12 BTU IN OF LAND IS IMPACTED. 2199

1557 199

THE ENERGY REQUIREMENT FOR A SODA ASH OPERATION IS 6.66 KWH/1000 299
GAL OF WATER TREATED (FROM INFORMATION IN REF. (1106)). THUS, 399
FOR A 0.4 MMGAL/D OPERATION THE ENERGY CONSUMED AMOUNTS TO 499
1.32E4 KWH/1.0E12 BTU. THE REAL ENERGY CONSUMPTION IS 3 TIMES 599

THE BTU EQUIVALENT OF THE ELECTRICITY CONSUMED. ON A 1.0E12 BTU IN BASIS THE ENERGY CONSUMPTION IS 6.29E7 BTU. THIS IS IN ADDITION TO THE ENERGY UTILIZATION DURING THE AUGERING OPERATION, I.E., 8.63E8 BTU/1.0E12 BTU IN (FOOTNOTE 1010).

1558

FOR THE MODIFIED BLOCK CUT MINING TECHNIQUE, SOLID WASTE IS PRODUCED ONLY DURING THE BOX CUT. HENCE, FOR A SLOPE ANGLE OF 28 DEGREES, A BENCH WIDTH OF 150 FT, A 15 FT RIM OF BLOSSOM COAL, AND A BOX CUT OF 600 FT IN LENGTH, 0.216 MMT OR 141 T/1.0E12 BTU IN OF SOLID WASTE ARE PRODUCED (SUBSEQUENT TO THE BOX CUT 50 MMT OF COAL ARE REMOVED OVER A 25 YR PERIOD). THE LENGTH OF THE BOX CUT IS BASED ON 250 FT LONG SECOND AND THIRD CUTS (1104) AND ALLOWS FOR EXPANSION.
THE SOLID WASTE PRODUCED FROM THE SODA ASH TREATMENT FACILITY AMOUNTS TO 257 T/1.0E12 BTU IN (FOOTNOTE 1555).

1559

FOR CONTOUR MINING (SLOPES GREATER THAN 15 DEGREES) IT IS ASSUMED THAT THE MODIFIED BLOCK CUT METHOD IS EMPLOYED.
THE THICKNESS OF THE SEAM IS 4.2 FT (FOOTNOTE 1511), THUS 5.27 AC ARE OVERTURNED FOR EVERY 1.0E12 BTU EQUIVALENT TON IN (FOOTNOTE 1511). AT THE SAME TIME 1531 FT OF BENCH ARE CREATED. ASSUMING 50 FT STRIPS OF LAND ABOVE THE HIGHWALL AND ALONG THE OUTSLOPE ARE UTILIZED FOR THE DIVERSION DITCH AND FOR STOCKPILING THE TOPSOIL, RESPECTIVELY, ANOTHER 3.51 AC OF LAND ARE AFFECTED/1.0E12 BTU IN.
NOW ASSUMING 3 GROWING SEASONS ARE REQUIRED TO ESTABLISH AN HERBACEOUS COVER (FOOTNOTE 1556), THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT OF THE VARIABLE LAND USE (8.78 AC) IS 24.8 AC-YR/1.0E12 BTU IN.
THE SOLID WASTE GENERATED FROM THE BOX CUT (FOOTNOTE 1558) IS DISPOSED OF BY THE PARALLEL SLOPE METHOD. BY THE END OF 3 YRS THIS PLOT WILL BE RECLAIMED (AS MEASURED BY THE CRITERION IN FOOTNOTE 1556), THUS ITS CONTRIBUTION TO THE OVERALL LAND IMPACT IS NEGLIGIBLE. THE LAND USE BY THE SODA ASH TREATMENT FACILITY IS 0.100 AC-YR/1.0E12 BTU IN (FOOTNOTE 1556).
IT SHOULD BE NOTED THAT ALTHOUGH CONTOUR BACKFILLING IS AN INTEGRAL PART OF RECLAMATION IN THIS ANALYSIS, IN PRACTICE THIS MAY NOT BE THE RECOMMENDED APPROACH ON STEEPER SLOPES. IN SUCH A SITUATION EROSION OF THE CONTOUR BACKFILLED AREA MAY BE DIFFICULT TO PREVENT.

1560

THE ENERGY CONSUMPTION FOR STRIPPING BY THE MODIFIED BLOCK CUT METHOD IS NOT AVAILABLE AND WAS ASSUMED TO BE THE SAME AS CONVENTIONAL CONTOUR STRIPPING-1.06E10 BTU/1.0E12 BTU IN (FOOTNOTE 1512). THE ENERGY CONSUMED BY THE SODA ASH TREATMENT FACILITY IS 1.32E4 KWH/1.0E12 BTU OUT (FOOTNOTE 1557) OR 1.06E8 BTU/1.0E12 BTU IN.

1561

TO CONTROL SILTATION, THE RUNOFF FROM THE HAUL ROADS IS DIVERTED TO SETTLING PONDS PLACED ALONG THE ROADWAY (1100). IT IS ASSUMED THAT ALL THE SEDIMENT IS REMOVED.

1562

IT IS ASSUMED THAT A SETTLING POND IS REQUIRED FOR EACH MILE OF ROAD AND THAT EACH POND USES AN ACRE. THUS, 5 AC ARE UTILIZED FOR THE SETTLING POND (THE HAUL ROAD IS 4.7 MI IN LENGTH, FOOTNOTE 1515). THE LAND IMPACT IS 0.103 AC-YR/1.0E12 BTU. THIS IS IN ADDITION TO THE LAND IMPACTED BY THE ROAD - 0.632 AC-YR/1.0E12 BTU (FOOTNOTE 1515).

UNCONTROLLED

FUEL	REGION
COAL	SOUTHWEST

WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL. 12)

ROW	MINE-MON.	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/10^{12}BTU)	13 PARTIC-ULATES	14 NO_x
1	EXTRC	EXTRACTION														
2	SURFC	SURFACE														
3	STRP-	<10° SLOPE	0.00+00 1 1000	0.00+00 1 1000	0000	0000	0.00+00 1 1000	0.00+00 1	0.00+00 1 1000	0000	0.00+00 1	0000	0.00+00 1 0007	0000	6.59+00 5 1006	1.05+00 5 1006
4	TRNSP	TRANSPORTATION														
5	TRUCK	TRUCKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.76 02 5 1007	6.01 01 4 1007
6	PROCE	PROCESSING														
7	BREAK	PRIMARY BREAKING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1000	0000
8	SCLEN	ROUGH CLEANING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1000	0000
9	MIXING	MIXING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1000	0000
10	BRENE	BREAKING & MIXING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 1000	0000
11	DISTR	DISTRIBUTION														
12	UNITT	UNIT TRAIN	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.09+01 5 1012	1.50+00 4 1012
13	STORA	STORAGE														
14	ABOVE	ABOVE GROUND	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 1 0007	0000	0.00 01 5 1021	0000
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY. SEE FOOTNOTE 1600 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF SOUTHWESTERN COAL AND REGIONAL DESCRIPTION.

HITTMAN

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12}BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/ 10^{12}BTU)	LAND (ACRE-YR / 10^{12} BTU)	DEATHS / 10^{12} BTU	INJURIES / 10^{12} BTU	MAN-DAYS LOST/10^{12}BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12}BTU)	ROW
																1
																2
0000	8.50+00 5 1004	1.05+00 5 1004	7.67-02 5 1004	1.05-01 5 1004	6.30-01 5 1004	1.70-02 5 1004	8.48+00 5	4.14+02 3 1001	3.06+01 2 1002	0.00+00 1 1600	5.00+02 1 1600	6.70+01 1 1600	1991	8.10-01 2 1004	5.00+00 6 1003	3
																4
0000	1.78-02 . 1007	3.01-01 4 1007	3.00-02 6 1007	5.01-02 6 1007	3.30-01 6 1007	8.13-03 4 1007	8.52-01 5	0000	5.29-01 3 1008	0.00+00 1 1610	1.40-02 1 1610	1.71-01 1 1610	1002	1.00+00 2 1004	3.78+06 4 1008	5
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0000	0.00+00 1 1009	0000	0000	0000	0000	0000	0.00+00 1	0000	0000	0.00+00 1 1617	0.00+00 1 1617	0.00+00 1 1617	1002	1.00+00 1 1007	1.00+00 6 1010	7
0000	0.00+00 1 1009	0000	0000	0000	0000	0000	0.00+00 1	3.00+00 5 1010	0000	0.00+00 1 1617	0.00+00 1 1617	0.00+00 1 1617	1002	1.00+00 1 1007	0000	8
0000	0.00+00 1 1009	0000	0000	0000	0000	0000	0.00+00 1	0000	0000	0.00+00 1 1617	0.00+00 1 1617	0.00+00 1 1617	1002	1.00+00 1 1007	0000	9
0000	0.00+00 1 1009	0000	0000	0000	0000	0000	0.00+00 1	3.00+00 5 1010	0.93-01 4 1019	0.00+00 1 1617	0.00+00 1 1617	0.00+00 1 1617	1002	1.00+00 1 1009	2.07+00 5 1011	10
																11
0000	2.00+01 3 1012	1.30+00 6 1012	1.30+00 5 1012	1.00+00 4 1012	1.40+00 6 1012	2.34-01 4 1012	2.67+01 5	0000	6.72+01 4 1014	0.89-03 4 1015	5.34+01 4 1015	4.00+01 4 1015	1002	1.00+00 3 1001	0.00+00 2 1012	12
																13
0000	0.00-01 3 1021	0000	0000	0000	0000	0000	0.00-01 3 1021	0000	2.00+00 2 1020	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 3 1007	1.00+00 5 1022	14
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TABLE 11. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED SOUTHWEST REGION OF COAL SUPPLY

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FOOTNOTES FOR TABLE 11

1600

FOR THIS STUDY THE SOUTHWEST REGION IS COMPRISED SOLELY BY THE STATE OF NEW MEXICO. THE FOCUS IS ON THE SAN JUAN BASIN, AND IN PARTICULAR, THE NAVAJO AND THE MCKINLEY MINES SUPPLYING THE FOUR CORNERS AND THE CHOLLA POWER PLANTS, RESPECTIVELY. THE AVERAGE CALORIC CONTENT OF THE COAL FROM THESE TWO MINES IS ABOUT 9820 BTU/LB, AND THE MEAN ASH AND SULFUR CONTENT IS 15.7 PC AND 0.6 PC, RESPECTIVELY. THE FOUR CORNERS PLANT REQUIRES BY CONTRACT, A HEATING VALUE OF 9000 BTU/LB AND THE AVERAGE ASH CONTENT OF COAL RECEIVED IS 23.5 PC (1066,3-12,6-10). THE AVERAGE SULFUR CONTENT OF THE COAL FROM THE NAVAJO MINE IS ABOUT 0.8 PC (1066,6-9). THE TIPPLE ANALYSIS OF THE COAL FROM THE MCKINLEY MINE INDICATES A CALORIC CONTENT OF 10640 BTU/LB, 7.9 PC ASH AND 0.42 PC SULFUR (1040,19). THE DENSITY OF THE COAL IS ABOUT 81 LB/CF (1050).
FOR THE GIVEN HEAT VALUE, 1.0E12 BTU ARE EQUIVALENT TO 51000 T OF COAL.

1601

THE AVERAGE DEPTH OF THE OVERBURDEN IN 1965 WAS 47.9 FT (1017), WHICH IS THE APPROXIMATE DEPTH OF THE OVERBURDEN REMOVED DURING BOX CUTTING (1040,13,20). IN AREA STRIPPING ALL OF THE OVERBURDEN, EXCEPT THAT WHICH IS REMOVED DURING THE BOX CUT, IS SPOILED IN BANKS WITHIN THE PIT. HENCE, THE SOLID WASTE IS PRODUCED ONLY DURING THE INITIAL EXCAVATION.
DUE TO THE VARIABILITY OF THE COAL CHARACTERISTICS WITHIN THE SEAM AT THE NAVAJO MINE, ABOUT 5 PITS ARE MINED SIMULTANEOUSLY AND THE COAL FROM THE DIFFERENT PITS ARE BLENDED TO MEET CONTRACT SPECIFICATIONS (1040,13). THUS, 5 BOX CUTS ARE REQUIRED.
ASSUMING THAT, ON THE AVERAGE, 5 AC (PIT SIZE OF ROUGHLY 100 FT BY 2000 FT, (1007)) ARE EXCAVATED FOR THE BOX CUT, ABOUT 2.61E6 T OF SOLID WASTE ARE PRODUCED. APPROXIMATELY 260 MMT OF COAL FROM THE NAVAJO MINE ARE COMMITTED TO THE FOUR CORNERS PLANT (1040,12). THUS, THE SOLID WASTE IS GENERATED AT A RATE OF 414 T/1.0E12 BTU IN THE GROUND.

1602

THE AVERAGE SEAM THICKNESS OF COAL SURFACE MINED IN NEW MEXICO DURING 1965 WAS 11.8 FT (1017). THIS IS ASSUMED TO APPLY FOR CURRENT MINING.
IN THIS REGION, AREA STRIPPING IS THE PREDOMINANT MINING TECHNIQUE EMPLOYED. SINCE RECLAMATION HAS NOT BEEN SUCCESSFUL, NO RECLAMATION IS ASSUMED.
FOR 1.0E12 BTU EQUIVALENT T IN, 2.45 AC OF LAND ARE OVERTURNED. THE TIME AVERAGED (OVER 25 YRS) LAND IMPACT IS THEREFORE, 30.6 AC-YR/1.0E12 BTU IN.

IN A PILE AVERAGING 30 FT IN HEIGHT, 39.9 AC ARE OCCUPIED BY THE SOLID WASTE PILE. THUS, FOR AN ANNUAL PRODUCTION OF ABOUT 8.5 MMT (REQUIREMENT FOR THE FOUR CORNERS PLANT (1040,143). THIS FIGURE IS USED SINCE THE SOLID WASTE IS BASED ON THE OPERATIONS AT THE NAVAJO MINE.) THE LAND IMPACT IS 0.194 AC-YR/1.0E12 BTU IN (FOOTNOTE 1601).

1603

BY LINEARLY INTERPOLATING THE DATA BETWEEN A 1 AND A 5 MMT/YR AREA STRIPPING OPERATION IN THE SOUTHWEST (1041,74,82) THE ENERGY REQUIREMENT FOR A 2 MMT/YR OPERATION IS ESTIMATED. DIESEL FUEL IS ASSUMED TO COST $0.20/GAL AND ELECTRICAL POWER $0.015/KWH. THUS, FOR DIESEL FUEL AND ELECTRICAL EXPENSES

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AMOUNTING TO $0.0275/T AND $0.153/T, RESPECTIVELY, THE TOTAL 799
ENERGY CONSUMPTION IS 6.28E9 BTU/1.0E12 BTU EQUIVALENT T 899
EXTRACTED. THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU 999
EQUIVALENT OF THE ELECTRICAL ENERGY CONSUMPTION TO THE FUEL 1099
USAGE. ON A 1.0E12 BTU IN BASIS, THIS IS 5.09E9 BTU CONSUMED. 1199

1604 199

DIESEL FUEL CONSUMPTION FOR AN AREA STRIPPING OPERATION IS ESTI- 299
MATED TO BE 5680 GAL/1.0E12 BTU IN (FOOTNOTE 1603). THE 399
EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7) ASSUMING 499
THE CHARACTERISTICS OF A DIESEL TRUCK ENGINE. BEING AN ARID 599
AREA, WIND EROSION AND FUGITIVE DUST ARE PROBLEMS TO CONTEND 699
WITH. IT IS ASSUMED THAT PARTICULATES ARE EMITTED AT A RATE 799
OF 428 LB/AC-YR, WHICH IS THE RATE OF WIND EROSION FOR THE MORE 899
ERROSIVE REGION OF THE SOUTHERN GREAT PLAINS (1211,18). HENCE, 999
6.55 T OF PARTICULATES ARE EMITTED FOR EVERY 1.0E12 BTU IN 1099
(FOOTNOTE 1602). 1199

1605 199

DUE TO THE HIGH ALKALINE CONTENT OF THE OVERBURDEN, ACID WATER 299
FORMATION IS PREVENTED AND DISPOSAL OF WATER ACCUMULATED IN 399
THE PITS SHOULD PRESENT NO PROBLEM. THE MORE USUAL PRACTICE 499
IN THIS AREA IS TO ALLOW THE WATER TO EVAPORATE OR SEEP INTO 599
THE SPOILS (1040,65). 699
SINCE RAINFALL IS VERY LIMITED, THE RUNOFF CAN EASILY BE 799
DIVERTED AWAY FROM THE PIT. THE MINE PITS HAVE NOT INTERSECTED 899
ANY GROUNDWATER TO DATE, BUT MAY DO SO IN THE FUTURE. DISPOSAL 999
OF GROUNDWATER, WHEN ENCOUNTERED, SHOULD NOT PRESENT ANY 1099
PROBLEM. ASIDE FROM ALLOWING THE WATER TO EVAPORATE, IT COULD 1199
BE UTILIZED FOR DUST SUPPRESSION OR IRRIGATION OF THE RESEEDED 1299
SPOIL BANKS. 1399

1606 199

THE AVERAGE DISTANCE FROM MINE TO TIPPLE IS ABOUT 3.25 MI (3.5 MI 299
FOR THE NAVAJO MINE AND 3.0 MI FOR THE MCKINLEY MINE (1040,21, 399
148)). DATA FROM STUDIES CONDUCTED IN EASTERN KENTUCKY (1024, 499
1031,1032,1033,1034) INDICATE AN AVERAGE HAUL ROAD RIGHT-OF- 599
WAY OF 6.4 AC/MI. ASSUMING A PRODUCTION OF 2 MMT/YR, 2.55 PC 699
OF THE ROAD USAGE IS ATTRIBUTED TO THE THE TRANSPORT OF 799
1.0E12 BTU EQUIVALENT T. HENCE, THE LAND IMPACT IS 0.529 AC- 899
YR/1.0E12 BTU. 999

1607 199

THE AVERAGE TRUCK CAPACITY IS 79.5 T (1040,21,148) AND THE MEAN 299
HAULAGE DISTANCE IS 3.25 MI (FOOTNOTE 1606). ASSUMING A GROSS 399
TO TARE WEIGHT RATIO OF 2.5 TO 1, A ROUND TRIP AMOUNTS TO 603 499
TMI. FUEL CONSUMPTION IS 7 GAL/1000 TMI (0002,3-7). HENCE, 599
2710 GAL OF DIESEL FUEL ARE CONSUMED FOR THE HAULAGE OF 1.0E12 699
BTU EQUIVALENT T. THE EMISSION FACTORS ARE OBTAINED FROM REF. 799
(0002,3-7). 899
FUGITIVE DUST FROM THE HAUL ROADS IS ASSUMED TO BE SUPPRESSED 999
BY WATERING DOWN THE ROADS WITH OR WITHOUT CHEMICAL ADDITIVES. 1099

1608 199

DIESEL FUEL CONSUMPTION AMOUNTS TO 2710 GAL/1.0E12 BTU. THUS, THE 299
ENERGY CONSUMPTION IS 3.76E8 BTU (FOOTNOTE 1607). 399

1609 199

ALL CONVEYORS AND CRUSHING FACILITIES ARE ENCLOSED AND WATER SPRAY 299
SYSTEMS ARE EFFECTIVE IN CONTROLING DUST (1040,148). 399

1610 199

A CRUSHER OPERATING AT 275 T/HR AND CRUSHING TO A TOPSIZE OF 1.5 299
IN. REQUIRES A 140 HP MOTOR (1014,7-14). THUS, 1.94E4 KWH OF 399
ENERGY ARE UTILIZED TO CRUSH 1.0E12 BTU EQUIVALENT T OF COAL. 499
THE REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF 599
THE ELECTRICAL ENERGY CONSUMED. 699

1611

ENERGY CONSUMPTION AT A CRUSHING AND SIZING PLANT IS ABOUT 2.07E9 BTU/1.0E12 BTU EQUIVALENT T PROCESSED. OF THE TOTAL CONSUMPTION, 1.81E5 KWH IS ELECTRICITY AND 2.91E8 BTU IS OIL (1064, 12A-16,39). THE TOTAL IS OBTAINED BY ADDING 3 TIMES THE BTU EQUIVALENT OF THE ELECTRICAL CONSUMPTION TO THE OIL USAGE.

1612

THE HAULAGE DISTANCE FOR TRANSPORT BY UNIT TRAIN IS 100 MI, WHICH IS THE HAULAGE DISTANCE BETWEEN THE MCKINLEY MINE AND THE CHOLLA POWER PLANT (THE CRUSHING PLANT FOR THE NAVAJO MINE IS ADJACENT TO THE FOUR CORNERS PLANT AND CONVEYORS ARE USED TO TRANSPORT THE COAL FROM THE BLENDING AREA TO THE POWER PLANT. (1060,7-9)). THE ENERGY CONSUMPTION IS 690 BTU/TMI (FOOTNOTE 7013), OR 0.005 GAL OF DIESEL FUEL/TMI. EACH TRAIN IS ASSUMED TO CARRY A 9000 T LOAD (100 CARS AT 90 T/CAR (1040, 21) AND THE GROSS TO TARE WEIGHT RATIO OF THE CARS IS 4 TO 1 (FOOTNOTE 1005). THUS, EACH ROUND TRIP AMOUNTS TO 1.5E6 TMI, AND 4.25E4 GAL OF FUEL ARE CONSUMED FOR EACH 1.0E12 BTU EQUIVALENT T TRANSPORTED. THE EMISSION FACTORS ARE OBTAINED FROM REF. (0002,3-7).

WINDAGE LOSSES AMOUNT TO .04 PC OF THE TOTAL SHIPMENT AND ARE ATTRIBUTED MAINLY TO HANDLING AT EITHER END POINT. THUS, 20.4 T OF PARTICULATES ARE RELEASED.

1613

DIESEL FUEL CONSUMPTION BY THE UNIT TRAIN IS 4.25E4 GAL/1.0E12 BTU. THUS, THE ENERGY CONSUMPTION AMOUNTS TO 5.89E9 BTU. (FOOTNOTE 1612).

1614

THE TOTAL MILES OF RAILROAD OPERATED WEST OF THE MISSISSIPPI IN 1971 WAS 119000 MI (0033,59) AND OF THE TOTAL TONNAGE OF FREIGHT HAULED DURING THE SAME YEAR IN THIS DISTRICT, COAL ACCOUNTED FOR 9 PC (0039,27), OR 48.8E06 TONS. OF THIS 16.7 PC ORIGINATED IN NEW MEXICO. ASSUMING A RIGHT-OF-WAY OF 6 AC/MI, THE LAND IMPACT IS 67.2 AC-YR/1.0E12 BTU.

1615

IN THE STATES WEST OF THE MISSISSIPPI, RAILWAY ACCIDENTS CLAIMED 714 LIVES AND INJURED 5700 PERSONS (0006,17,54), AND AN AVERAGE OF 93 MAN-DAYS WERE LOST PER INJURY (0006,4).

FOR EVERY 1.0E12 BTU EQUIVALENT T OF COAL TRANSPORTED 0.0669 FATALITIES AND 0.534 NON-FATAL INJURIES OCCURED IN THIS REGION AND 49.6 MAN-DAYS WERE LOST. (FOOTNOTE 1614, COAL TRANSPORTED).

1616

THE OCCUPATIONAL HEALTH STATISTICS FOR HAULAGE FROM MINE TO TIPPLE ARE OBTAINED FROM (1210,80/91 AND 1070) AND REPRESENT AN AVERAGE FOR 1969 AND 1970.

1617

THERE WERE NO INJURIES, FATAL OR NON-FATAL, AT ANY OF THE PREPARATION PLANTS IN NEW MEXICO DURING 1969 AND 1970.

1618

IT IS ASSUMED THAT 0.006 PC OF THE FEED TO THE CRUSHING PLANT IS TRAMP IRON AND IS REMOVED PRIOR TO CRUSHING. THUS, 3.06 T OF TRAMP IRON ARE COLLECTED FOR EVERY 1.0E12 BTU PROCESSED. THE PERCENTAGE OF TRAMP IRON IS ESTIMATED FROM INFORMATION IN REF. (1059,6-31) ASSUMING THAT THE LARGE PLANT PROCESSES 1000 T/HR.

1619

ABOUT 35 ACRES ARE REQUIRED FOR THE CRUSHING PLANT AND THE SUPPORTING FACILITIES. ASSUMING THE PROCESSING OF 2 MMT/YR, THE LAND IMPACT IS 0.893 AC-YR/1.0E12 BTU.

1620 199

THE COAL IN THIS AREA IS USUALLY STORED ABOVE GROUND. AT THE FOUR 299
CORNERS POWER PLANT, THE COAL IS STACKED BY CONVEYORS IN PILES 399
90 FT WIDE AND 800 FT LONG, EACH CONTAINING ABOUT 30000 T OF 499
BLENDED COAL (1040,148). THUS, THE LAND IMPACT IS 2.80 AC-YR/ 599
1.0E12 BTU. 699

1621 199

AS IN THE CASE FOR THE MINES,IT IS ASSUMED THAT 428 LB/AC-YR OF 299
COAL FINES WILL BECOME AIRBORNE AS PARTICULATES DUE TO THE 399
WINDAGE. THUS, 0.6 T/1.0E12 BTU OF PARTICULATES ARE EMITTED. 499

1622 199

ENERGY CONSUMPTION FOR THE MOVEMENT OF COAL BY CONVEYORS FOR 299
STORAGE AMOUNTS TO 1.86E4 KWH/1.0E12 BTU (FOOTNOTE 1058). THE 399
REAL ENERGY CONSUMPTION IS 3 TIMES THE BTU EQUIVALENT OF THE 499
ELECTRICAL ENERGY CONSUMED. 599

		CONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		FUEL	REGION														
		COAL	SOUTHWEST	WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL. 12)													
ROW	MNE-MON.	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS				SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO
						PO_4	NO_3	OTHER	TOTAL (DS)								
1	EXTRC	EXTRACTION															
2	SURFC	SURFACE															
3	STRP-	<15° SLOPE		0.00+00 1 1603	0.00+00 1 1605	0998	0998	0.00+00 1 1605	0.00+00 1	0.00+00 1 1603	0998	0.00+00 1	0998	0.00+00 1 0997	0998	2.30-05 5 1829	1.00+00
4	TRANS	TRANSPORTATION															
5	TRUCK	TRUCKING		0998	0998	0998	0998	0998	0998	0.00+00 2 1827	0998	0.00+00 2	0998	0998	0998	1.76-02 5 1607	5.01-01
6	PROCE	PROCESSING															
7	BREAK	PRIMARY BREAKING		0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0.00+00 1 1600	
8	RCLEN	ROUGH CLEANING		0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0.00+00 1 1600	
9	MIXING	MIXING		0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0.00+00 1 1600	
10	BREKS	BREAKING & SIZING		0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0.00+00 1 1600	
11	DISTR	DISTRIBUTION															
12	UNITT	UNIT TRAIN		0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	2.00+01 5 1612	1.00+00
13	STORA	STORAGE															
14	AGRIS	ABOVE GROUND		0998	0998	0998	0998	0998	0998	0998	0998	0998	0998	0.00+00 1 0997	0998	0.00-01 5 1821	
15																	
16																	
17																	
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 1600 FOR MEASURE EQUIVALENTS OF 10^{12} BTU, SULFUR AND ASH CONTENTS OF SOUTHWESTERN COAL AND REGIONAL DESCRIPTION.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS / 10^{12} BTU	LAND (ACRE-YR / 10^{12} BTU)	DEATHS / 10^{12} BTU	INJURIES / 10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	ROW
																1
																2
0000	2.18+00 5 1020	1.05+00 5 1004	7.67-02 5 1004	1.05+01 5 1004	6.19+01 5 1004	1.70+02 5 1004	4.28+00 5	4.14-02 5 1001	1.10+01 2 1020	0.00+00 1 1000	5.00-02 1 1000	6.70+01 1 1000	1001	8.11+01 5 1004	5.11+00 5 1020	3
																4
0000	1.70-02 5 1007	5.01-01 6 100	3.00+00 6 1007	5.01-02 6 1007	3.30+01 6 1007	8.13+03 6 1007	8.52-01 5	0000	5.00-01 3 1015	0.00+00 1 1010	1.40-03 1 1010	1.71-01 1 1010	1002	1.00+00 2 1000	1.70+00 6 1000	5
																6
0000	0.00+00 1 1000	0000	0000	0000	0000	0000	0.00+00 1	0000	0000	0.00+00 1 1017	0.00+00 1 1017	0.00+00 1 1017	1002	1.00+00 1 1007	1.90+00 6 1010	7
0000	0.00+00 1 1000	0000	0000	0000	0000	0000	0.00+00 1	3.00+00 5 1010	0000	0.00+00 1 1017	0.00+00 1 1017	0.00+00 1 1017	1002	1.00+00 1 1007	0000	8
0000	0.00+00 1 1000	0000	0000	0000	0000	0000	0.00+00 1	0000	0000	0.00+00 1 1017	0.00+00 1 1017	0.00+00 1 1017	1002	1.00+00 1 1007	0000	9
0000	0.00+00 1 1000	0000	0000	0000	0000	0000	0.00+00 1	3.00+00 5 1010	4.85+01 6 1010	0.00+00 1 1017	0.00+00 1 1017	0.00+00 1 1017	1002	1.00+00 1 1000	3.01+00 5 1010	10
																11
0000	2.00+01 5 1010	1.50+00 6 1010	1.30+00 6 1010	1.00+00 6 1010	1.00+00 6 1010	2.34-01 6 1010	7.67+01 5	0000	6.72+01 6 1014	0.00-02 6 1010	5.34-01 4 1010	5.00+01 6 1010	1002	1.00+00 5 1001	0.00+00 5 1010	12
																13
0000	0.00-01 5 1021	0000	0000	0000	0000	0000	0.00-01 5 1021	0000	2.00+00 2 1020	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	1002	0.00-01 5 1007	1.00+00 5 1022	14
																15
																16
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																18
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TABLE 12. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED SOUTHWEST REGION OF COAL SUPPLY

FOOTNOTES FOR TABLE 12

1625

IN THE SAN JUAN BASIN, 2.45 AC OF LAND ARE OVERTURNED PER 1.0E12 BTU IN (FOOTNOTE 1602).
IN TIME AVERAGING THE LAND IMPACT, CONSIDERATION MUST BE GIVEN TO THE EFFECTS OF RECLAMATION, WHICH IN THIS CASE IMPLIES CONTOUR BA[illegible]LLING, REDISTRIBUTION OF TOPSOIL, SEED BED PREPARATION, T[illegible]NG (GOUGING) AND REVEGETATION. THE CRITERION FOR REVEGE[illegible] THE ESTABLISHMENT OF AN HERBACEOUS COVER SUFFICIENT [illegible]ZE THE SURFACE AGAINST EROSION. FOR THE PURPOSE OF Q[illegible]ATION,5 YRS ARE ASSUMED TO BE SUFFICIENT TO RECLAIM THE LAND TO THE ABOVE CRITERION (SEE FOOTNOTE 1230). THIS DOES NOT IMPLY THAT 5 YRS ARE ADEQUATE IN PRACTICE. RECLAMATION STUDIES FOR THIS AREA HAVE BEGUN ONLY RECENTLY AND NO CONCLUSIVE RESULTS HAVE BEEN PRESENTED.
THE TIME AVERAGED IMPACT IS THEREFORE 11.0 AC-YR/1.0E12 BTU IN (THE LAND USED FOR STORAGE OF THE WASTE IS ASSUMED TO BE ZERO, I.E., INSTANTANEOUS RECLAMATION).

1626

ASSUMING A SPOIL PILE HEIGHT OF 75 FT AND GEOMETRICALLY UNIFORM PARALLEL SPOIL BANKS RESTING AT AN ANGLE OF REPOSE OF 38 DEGREES, THE PEAK TO PEAK DISTANCE IS ABOUT 100 FT. THUS, THE ENERGY CONSUMED TO LEVEL THE SPOIL PILE AMOUNTS TO 3920 HP-HR/AC ((1222,67) AND ASSUMING A 6 PC PERFORMANCE EFFICIENCY).
THUS, 2 45E7 BTU/1.0E12 BTU IN ARE EXPENDED (FOOTNOTE 1602, LAND TO BE RECLAIMED).
THIS ENERGY USE IS IN ADDITION TO THE ENERGY REQUIRED FOR THE MINING OPERATION--5.09E9 BTU/1.0E12 BTU IN (FOOTNOTE 1603).

1627

TO CONTROL SEDIMENTATION, THE RUNOFF FROM THE HAUL ROADS IS DIVERTED TO SETTLING PONDS PLACED AT INTERVALS ALONG THE ROADWAY (1100). FOR THE 3.25 MI LONG HAUL ROADS (FOOTNOTE 1606) 2 SETTLING PONDS ARE ASSUMED TO BE ADEQUATE AND, BECAUSE OF THE LOW RAINFALL, SUFFICIENT TO CONTAIN ALL OF THE RUNOFF. THE WATER CAN BE USED TO SUPPRESS THE DUST FROM THE HAUL ROADS, OR ALLOWED TO EVAPORATE.

1628

THE HAUL ROAD LAND IMPACT IS 0.529 AC-YR/1.0E12 BTU (FOOTNOTE 1606). THE SETTLING PONDS ARE ASSUMED TO OCCUPY 2 AC (1 AC PER POND). THUS, THE LAND IMPACT FOR THE SETTLING PONDS IS 0.0509 AC-YR/1.0E12 BTU (2 MMT/YR HAULED ON THE ROADS).
THE TOTAL LAND IMPACT IS 0.580 AC-YR/1.0E12 BTU.

1629

BASED ON AN EROSION RATE OF 428 LB/AC-YR (FOOTNOTE 1604) AND A TIME AVERAGED LAND IMPACT OF 11.0 AC-YR/1.0E12 BTU IN (FOOTNOTE 1625), 2.35 TON PART/1.0E12 BTU IN ARE GENERATED.
THIS IS IN ADDITION TO THE PARTICULATES FROM THE DIESEL FUEL CONSUMED (FOOTNOTE 1604).

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IV. OIL SUPPLY

A. Introduction

The environmental impacts, energy requirements, and costs associated with the production, transportation, processing, and distribution of crude oil and refinery products are presented on a national average basis for the "uncontrolled" and "controlled" petroleum supply cases. Also presented are five regional analyses, with and without environmental controls, which reflect the use of specific crude or residual fuel oils. The regional analysis is based primarily on the different sulfur contents of the crudes and is generally constrained by the lack of regional data. Many refineries run a blend of crude feedstocks which precludes an environmental impact assessment of any specific crude oil.

The crude oil processing activity of the petroleum supply system is comprised of a national average refinery row and rows representing the constituent process components contained in the national average refinery. However, in keeping with the table entry format, the elements in each row are based on an energy input of 10^{12} Btu/yr. Thus, for example, the entries in the row labeled Catalytic Cracking have been computed based on an input of 10^{12} Btu/yr to this process (equivalent to 176,000 bbl of feedstock for this process). In contrast, the entries in the row labeled National Average Refinery have been computed based on an input of 10^{12} Btu/yr to the refinery (equivalent to 178,000 bbl of crude feedstock). The national average refinery, of course, is comprised of the component processes but the process capacities are as shown in Figure 11. It should also be understood, as noted above, that 10^{12} Btu/yr input to each process in <u>not</u> equivalent to 178,000 bbl of <u>crude</u> feedstock to each process. Rather, the appropriate petroleum derived feedstock (and heating value) is used as the basis for computing the bbl equivalents of 10^{12} Btu/yr at the process level. This information is provided in the footnotes.

The level of environmental control for the "uncontrolled" petroleum supply is taken as the application of present day environmental controls for the extraction, transportation, distribution, and conversion activities. The processing activity, on the other hand, represents a minimal level of environmental control for the "uncontrolled" case because of the lack of available data delineating the present degree of control in the refining industry. Also, using a minimum level of environmental control in the uncontrolled processing activity provides a better baseline for the application of controls to the refining industry. Consequently, the "uncontrolled" national

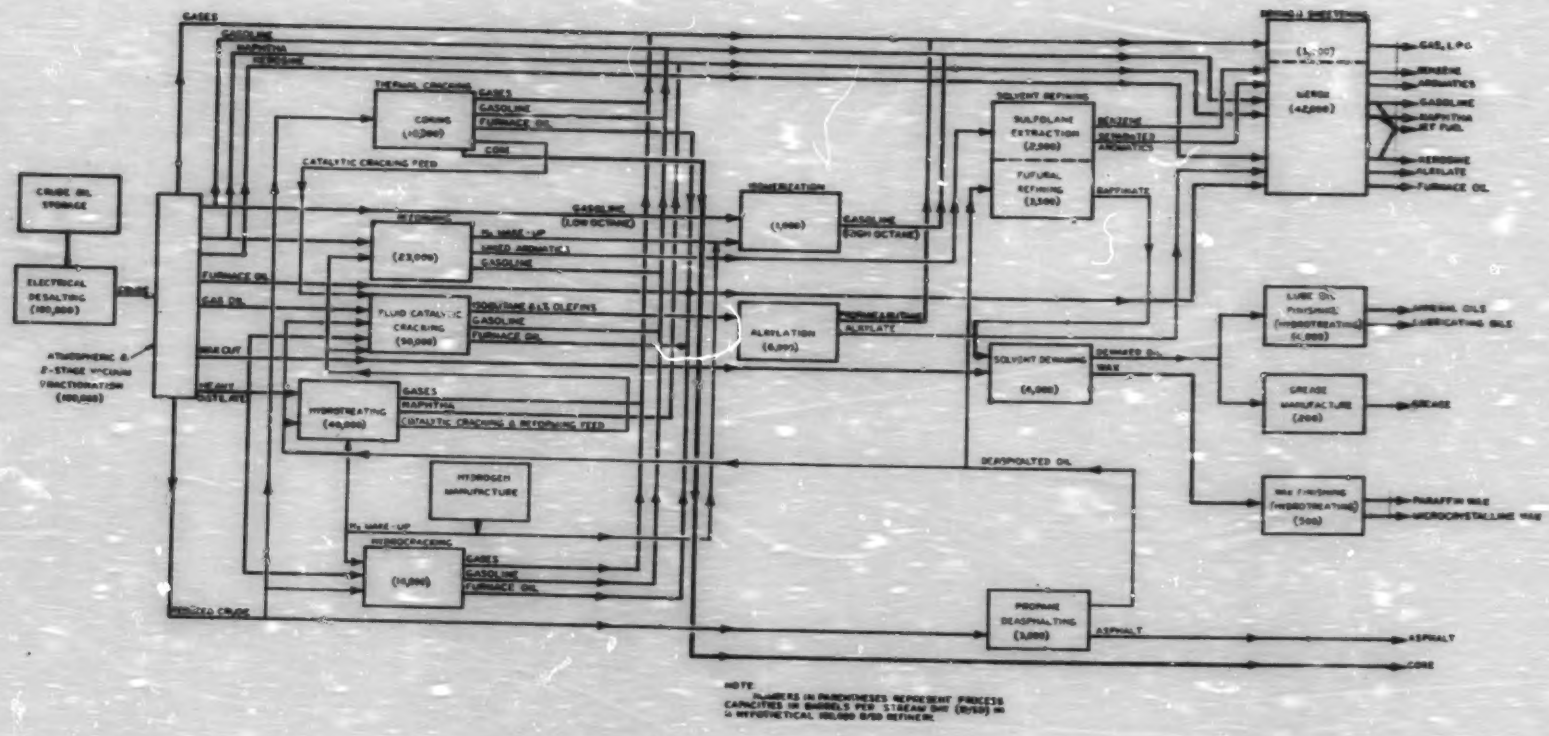

FIGURE 11. NATIONAL AVERAGE REFINERY

average petroleum refinery has only an API separator for the treatment of wastewater effluents, has no control for CO or particulates from catalytic cracking regenerators, uses fixed roof tanks for the storage of all crude and petroleum products, flares all H_2S from sour process gas streams, and releases thermal discharges associated with once-through river cooling systems. The "controlled" refinery, in contrast, requires the use of best practical control technology currently available for the treatment of wastewater effluents, the use of demonstrated air pollution control technology for compliance with the New Source Performance Standards for petroleum refineries, and the use of mechanical draft wet cooling towers to abate thermal discharges. It should be noted that end-of-pipe treatment (to reduce water effluents and thermal discharges) is shown only for the national average refinery row whereas specific air pollutant sources (process rows) are shown controlled at both the process and national average refinery levels. Generally speaking, the requirement for use of control technology in the "controlled" processing activity is mandated by existent or soon-to-be-implemented federal or state regulations. On the other hand, the existence of the "controlled" extraction, transportation, distribution, and conversion activities represents the use of control technology which merits consideration for future more comprehensive environmental regulation. This includes the use of double bottom construction on tankers to provide clean ballast storage and to reduce the risks of oil spills should a grounding occur and the use of a compression-liquefaction vapor recovery system for the control of hydrocarbon emissions from gasoline service stations.

The five regional analysis supply tables presented are based on the use of domestic onshore crude, domestic offshore crude, imported Canadian crude, imported Middle East crude, and imported South American residual fuel oil. The activity most sensitive to the regional characteristics of the crude is that of processing and, due to the lack of available data, only the sulfur content of the crudes has any discernible impact on refinery emission characteristics given in the tables. Figure 12 summarizes the crude oil properties used for the national and regional analyses.

The approach used in this analysis has been to alter refinery SO_x emissions or product sulfur contents according to the varying sulfur contents of the crude feedstock. It is realized, of course, that hydrodesulfurization of petroleum feedstocks can circumvent this result and is in fact being practiced today by refineries running sour crudes. This has not been employed in our analysis. In cases where a process within an activity predominates, only that process is included in the regional table. This is illustrated, for example, in the imported Canadian crude regional case by pipeline transport in the transportation activity.

Region	10^{12} Btu Equivalent (BBL)	Density (lb/BBL)	Sulfur Content (%)
Domestic Onshore	178000	305.6	0.81
Domestic Offshore	178000	305.6	0.61
Imported Canadian Crude	178000	305.6	0.59
Imported Middle East Crude	178000	305.6	1.92
Imported South American Residual	159000	331.1	1.50
National Average	178000	305.6	0.79

Figure 12. National and Regional Crude Oil Analyses

B. Impact Data Tables and Footnotes

		UNCONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		FUEL	REGION															
		OIL	NATIONAL	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)														AIR POLL
ROW	SEQ. MON.	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS				SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x
						PO_4	NO_3	OTHER	TOTAL (DS)									
1	EXTRC	EXTRACTION																
2	ONSHR	ONSHORE PRODUCTION		0000	0000	0000	0000	0000	0000	0000	1.55-01 3 2004	1.55-01 3	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007
3	OFFSR	OFFSHORE PRODUCTION		0000	0000	0000	0000	0000	0000	0000	1.29-00 3 2004	1.29-00 3	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007
4	TANSP	CRUDE OIL TRANSPORT																
5	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	6.00-02 3 2002	6.00-02 3	0000	0000	0000	1.72-01 3 2031	4.00+00 3 2031	2.57-01 3 2031
6	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	3.00-01 2 2020	3.00-01 3	0000	0000	0000	3.75-02 3 2024	3.37-01 3 2024	5.15-01 3 2024
7	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	3.00-01 2 2020	3.00-01 3	0000	0000	0000	3.75-02 3 2025	3.37-01 3 2025	5.15-01 3 2025
8	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.00-00 2 2007	7.00-00 3	0000	0000	0000	3.00+00 3 2038	2.17+00 3 2038	2.31+00 3 2038
9	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	[illegible]	0000	0000	0000	6.56-01 3 2029	1.87+01 3 2029	1.37+00 3 2029
10	TNKCS	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	[illegible]	0000	0000	0000	1.28+00 3 2030	3.84+00 3 2030	2.30+00 3 2030
11	PROCS	PROCESSING																
12	NAVRE	NATIONAL AVERAGE REFINERY		0000	0000	0000	0000	1.43+05 2 2006	1.58+01 3 2006	2.22+01 2 2006	8.00+00 2 2006	6.40+01 3	6.92+00 2 2006	2.02+01 2 2006	7.06+10 4 2006	8.16+00 3 2006	2.28+01 3 2006	2.60+02 3 2006
13	CRDTK	CRUDE OIL STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	8.90-01 3 2036	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007
14	DSALT	ELECTROSTATIC DESALTING		0000	0000	0000	0000	1.02+01 3 2005	2.23+01 3 2005	0000	1.07+00 3 2005	2.34+01 4	2.67-01 3 2005	2.55+00 3 2005	0.00+00 2 0007	2005	2005	2005
15	DSTIL	ATMOS. & VAC. DISTILLATION		0000	0000	0000	0000	6.90-02 3 2006	2.12+00 3 2006	0000	1.60+00 3 2006	4.72+00 4	1.78-02 3 2006	4.65-01 3 2006	1.50+10 3 2006	2.07-01 3 2006	2.34+00 3 2006	6.21-02 3 2006
16	CATCR	CATALYTIC CRACKING		0000	0000	0000	0000	0.00+00 3 2007	7.62+00 3 2007	0000	9.24+00 3 2007	1.72+01 4	1.30+00 3 2007	1.10+00 3 2007	1.74+10 3 2007	9.00+00 3 2007	0.07+00 3 2007	3.00+01 3 2007
17	CATRF	CATALYTIC REFORMING		0000	0000	0000	0000	8.50-02 3 2008	1.10+01 3 2008	0.00+00 3 0007	4.82+00 3 2008	6.01+00 3	0.00+00 3 0007	3.60+00 3 2008	3.83+09 3 2008	3.32-01 3 2008	3.82+00 3 2008	8.07-03 3 2008
18	DSTRT	DISTILLATE HYDROTREATING		0000	0000	0000	0000	2.72+00 3 2009	3.01+00 3 2009	0.00+00 3 0007	6.00-04 3 2009	3.01+00 3	8.80-01 3 2009	4.30+00 3 2009	5.37+09 3 2009	1.60-02 3 2009	1.67-01 3 2009	4.37-04 3 2009
19	COKG	DELAYED COKING		0000	0000	0000	0000	0000	2.39+00 3 2010	0000	4.83-01 3 2010	2.66+00 3	0000	2.54+00 3 2010	1.72+10 3 2010	5.10-01 3 2010	5.87+00 3 2010	1.36-02 3 2010
20	DSTLT	DISTILLATE HYDROCRACKING		0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 3	1.72-01 3 2011	3.87+00 3 2011	1.43+10 3 2011	2.72-01 3 2011	3.12+00 3 2011	8.10-03 3 2011
21	ISOME	ISOMERIZATION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+09 3 2012	1.60-01 3 2012	1.19+01 3 2012	3.83-03 3 2012
22	ALKYL	ALKYLATION		0000	0000	0000	0000	2.37+00 3 2013	3.38+01 3 2013	0000	1.10-02 3 2013	3.30-01 4	1.18+00 3 2013	1.10+01 3 2013	1.06+11 3 2013	6.25-01 3 2013	8.50+00 3 2013	2.60-03 3 2013
23	AROMA	AROMATICS EXTRACTION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.16+10 3 2014	0000	0000	0000
24	FURFR	FURFURAL REFINING		0000	0000	0000	0000	0000	0000	0000	2.48-01 3 2015	2.48-01 3	0000	0000	3.44+10 3 2015	5.62-01 3 2015	6.23+00 3 2015	1.62-02 3 2015
25	SLOWX	SOLVENT DEWAXING		0000	0000	0000	0000	0000	0000	0000	1.24-01 3 2016	1.24-01 3	0000	0000	7.90+10 3 2016	3.50-01 3 2016	6.42+00 3 2016	1.65-02 3 2016
26	HDTRT	HYDROTREATING		0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2018	1.25+00 3	8.23+00 3 2018	0000	6.41+06 3 2018	6.90-03 3 2018	6.20-02 3 2018	2.40-04 3 2018
27	GASTR	GASOLINE TREATING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019
28	LUBEH	LUBE OIL HYDROTREATING		0000	0000	0000	0000	2.64+00 3 2020	2.48+00 3 2020	0.00+00 3 0007	8.25-04 3 2020	2.60+00 3	8.25-01 3 2020	4.12+01 3 2020	2.78+10 3 2020	3.62-01 3 2020	4.16+00 3 2020	1.12-02 3 2020
29	GREAS	GREASE MANUFACTURE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
30	WXDEW	WAX DEWOLING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.56-01 3 2022	7.52+00 3 2022	1.87-02 3 2022
31	PROPA	PROPANE DEASPHALTING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.87+10 3 2017	1.01+06 3 2017	1.16+01 3 2017	3.03-02 3 2017
32	H2MFG	HYDROGEN MANUFACTURING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.47+11 3 2023	6.45+00 3 2023	5.67+01 3 2023	1.49-01 3 2023
33	RFSTO	REFINERY PRODUCT STORAGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	8.15-02 3 2037	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007
34	DSTR	PRODUCT DISTRIBUTION																
35	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	6.22-02 3 2062	6.22-02 3	0000	0000	0000	1.72-01 3 2032	4.00+00 3 2032	2.57-01 3 2032
36	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	3.06+01 2 2063	3.06+01 2	0000	0000	0000	3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032
37	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	3.06+01 2 2063	3.06+01 2	0000	0000	0000	3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032
38	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.00+00 2 2064	7.00+00 2	0000	0000	0000	3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032
39	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.56-01 3 2032	1.87+01 3 2032	1.37+00 3 2032
40	TNKCS	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032	3.84+00 3 2032	2.30+00 3 2032
41	PTERM	PRODUCT TERMINALS																
42	TNKST	STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
43	MRKT	MARKETING																
44	GASTT	AUTO GASOLINE TANK FILL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
45																		
46																		
47																		
48																		
49																		
50																		

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

HITTMAN

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/10^{12} BTU)							SOLIDS TONS / 10^{12} BTU	LAND (ACRE-YR / 10^{12} BTU)	OCCUPATIONAL HEALTH			POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	COST (DOLLARS/10^{12} BTU)			ROW
PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL			DEATHS / 10^{12} BTU	INJURIES / 10^{12} BTU	MAN-DAYS LOST/10^{12} BTU				FIXED COST	OPERATING COST	TOTAL COST	
																		1
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0000	3.03+00 2 2001	8.20-05 4 2033	3.75-03 4 2033	1.28-01 4 2033	3000	3.00-01 3 2000	0000	8.15+06 4 2001	0000	0000	2
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0000	3.54-01 2 2001	5.70-08 4 2033	2.61-04 4 2000	8.88-03 4 2033	2000	3.00-01 3 2000	0000	5.75+04 4 2001	0000	0000	3
																		4
1.72-01 3 2031	6.00+00 3 2031	3.87-01 3 2031	4.00-01 3 2031	2.00+00 3 2031	7.94-02 3 2031	8.87+00 3	0000	8.38+01 2 2002	3.38-08 4 2034	2.79-03 4 2034	0.48-02 4 2034	2057	1.00+00 2 2081	3.00+09 2 2081	0000	0000	2.20+04 2 2073	5
3.75-02 3 2024	3.37-01 3 2024	5.15-01 3 2024	1.00-02 3 2024	8.16-03 3 2024	3.30-03 3 2024	9.18-01 3	0000	1.81-01 3 2071	0000	0000	0000	2000	9.89-01 2 2002	3.97+10 2 2002	0000	0000	2.04+05 3 2077	6
3.75-02 3 2025	3.37-01 3 2025	5.15-01 3 2025	1.00-02 3 2025	8.16-03 3 2025	3.35-03 3 2025	9.18-01 3	0000	1.01-01 3 2071	0000	0000	0000	2000	9.00-01 2 2002	3.97+10 2 2002	0000	0000	1.60+05 3 2000	7
3.02+00 3 2028	2.17+00 3 2028	2.31+00 3 2028	1.60+00 3 2028	1.00+00 3 2028	1.00-01 3 2028	1.08+01 3	0000	1.61-01 3 2071	0000	0000	0000	2008	1.00+00 2 2003	2.32+10 2 2003	0000	0000	2.23+05 2 2074	8
6.90-01 3 2029	1.07+01 3 2029	1.37+00 3 2029	1.67+00 3 2029	1.16+01 3 2029	3.06-01 3 2029	3.63+01 3	0000	3.53+02 3 2087	0000	0000	0000	2000	0000	1.38+10 3 2020	0000	0000	5.98+04 2 2075	9
1.20+00 3 2030	3.84+00 3 2030	3.33+00 3 2030	2.98+00 3 2030	2.50+00 3 2030	5.00-01 3 2030	1.52+01 3	0000	1.98+01 3 2070	0000	0000	0000	2000	0000	1.42+10 2 2030	0000	0000	9.04+04 3 2076	10
																		11
5.30+00 3 2006	2.28+01 3 2006	2.60+02 3 2006	2.32+02 3 2006	6.11+02 3 2006	3.73+00 3 2006	1.12+03 3 2006	2.57+00 3 2006	1.03+01 4 2000	4.35-06 3 2041	3.62-02 3 2041	2.05+00 3 2041	2000	9.32-01 3 2003	5.00+10 2 2004	7.08+04 2 2004	2.42+05 2 2004	3.10+05 2	12
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	6.72+01 3 2036	0.00+00 2 0007	0.00+00 2 0007	6.72+01 3	0000	1.61-01 3 2071	0000	0000	0000	2002	8.00-01 2 2000	0.00+00 2 0007	1.05+04 3 2007	7.32+03 3 2007	1.79+04 3	13
2005	2005	2005	2005	2000	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.00+07 2 2005	4.00+02 3 2043	1.00+03 3 2043	1.46+03 3	14
3.07-01 3 2006	2.30+00 3 2006	6.21-03 3 2006	2.00+01 3 2006	4.16-03 3 2006	1.04-01 3 2006	3.09+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	2.21+10 2 2006	8.61+03 3 2043	4.65+04 3 2043	5.31+04 3	15
5.00+00 3 2007	9.07+00 3 2007	1.43+01 3 2007	3.72+01 3 2007	1.21+03 3 2007	8.57+00 3 2007	1.29+03 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	3.35+10 2 2007	1.25+04 3 2045	7.19+04 3 2045	8.44+04 3	16
3.32-01 3 2008	3.62+00 3 2008	8.07-03 3 2008	1.00+00 3 2008	6.65-03 3 2008	1.30-01 3 2008	1.61+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	4.30+10 2 2008	2.02+04 3 2046	1.31+05 3 2046	1.51+05 3	17
1.00-02 3 2009	1.07-01 3 2009	4.37-06 3 2009	1.30+01 3 2009	2.01-04 3 2009	7.27-03 3 2009	1.60+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.50+09 2 2009	4.17+03 3 2044	6.18+04 3 2044	6.60+04 3	18
6.20-01 3 2010	5.07+00 3 2010	1.30-02 3 2010	6.00+01 3 2010	1.66-02 3 2010	2.00-01 3 2010	1.74+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	6.17+10 2 2010	3.80+04 3 2047	8.51+04 3 2047	1.24+05 3	19
8.72-01 3 2011	3.13+00 3 2011	8.18-03 3 2011	1.30+01 3 2011	5.66-03 3 2011	1.30-01 3 2011	3.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	4.56+10 2 2011	2.68+04 3 2048	2.15+05 3 2048	2.42+05 3	20
1.00-01 3 2012	1.13+01 3 2012	5.83-03 3 2012	1.34+01 3 2012	3.60-03 3 2012	8.72-02 3 2012	2.50+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	2.33+10 2 2012	3.84+04 3 2049	1.30+05 3 2049	1.71+05 3	21
8.20-01 3 2013	8.50+00 3 2013	1.40-03 3 2013	5.11+01 3 2013	1.05-02 3 2013	4.13-01 3 2013	6.10+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	8.80+10 2 2013	1.07+04 3 2050	2.07+05 3 2050	3.17+05 3	22
0000	0000	0000	1.61+01 3 2014	0000	0000	1.61+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0000	3.01+05 3 2058	4.10+05 3 2058	7.11+05 3	23
5.60-01 3 2015	8.23+00 3 2015	1.62-02 3 2015	7.21+00 3 2015	1.00-02 3 2015	2.71-01 3 2015	2.13+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	5.75+10 2 2015	4.20+04 3 2053	9.84+04 3 2053	1.41+05 3	24
6.50-01 3 2016	8.32+00 3 2016	1.65-02 3 2016	1.80+01 3 2016	1.10-02 3 2016	2.74-01 3 2016	2.82+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	7.08+10 2 2016	9.40+04 3 2054	1.50+05 3 2054	2.55+05 3	25
8.00-03 3 2018	8.20-02 3 2018	2.60-04 3 2018	4.00+01 3 2018	1.60-04 3 2018	6.00-03 3 2018	4.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.07+00 2 2018	1.02+04 3 2050	2.51+04 3 2050	3.53+04 3	26
0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0000	4.12+03 3 2055	8.20+03 3 2055	1.23+04 3	27
8.02-01 3 2020	4.10+00 3 2020	1.12-02 3 2020	1.30+01 3 2020	7.23-03 3 2020	1.81-01 3 2020	1.85+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	4.12+10 2 2020	1.10+04 3 2057	3.64+04 3 2057	4.82+04 3	28
0000	0000	0000	9.94+00 4 2021	0000	0000	9.94+00 5 2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0000	0000	0000	0000	29
8.86-01 3 2022	7.52+00 3 2022	1.07-02 3 2022	1.10+01 3 2022	1.31-02 3 2022	3.27-01 3 2022	2.04+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	8.61+10 2 2022	8.77+04 3 2099	8.00+04 3 2050	1.20+05 3	30
1.01+00 3 2017	1.16+01 3 2017	3.03-02 3 2017	1.11+01 3 2017	2.02-02 3 2017	5.04-01 3 2017	2.63+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.08+11 2 2017	1.69+04 3 2051	5.52+04 3 2051	7.21+04 3	31
6.65+00 3 2023	5.67+01 3 2023	1.40-01 3 2023	9.89+00 3 2023	9.89-02 3 2023	2.48+00 3 2023	7.38+01 3	0000	0000	0000	0000	0000	2001	5.03-01 2 2079	0.00+00 2 2079	7.38+04 2 2052	3.34+05 2 2052	4.08+05 2	32
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	9.33+01 3 2037	0.00+00 2 0007	0.00+00 2 0007	9.33+01 3	0000	1.46-01 3 2071	0000	0000	0000	2002	9.90-01 2 2000	0.00+00 2 0007	1.08+04 3 2000	7.30+03 3 2000	1.80+04 3	33
																		34
1.72-01 3 2032	4.00+00 3 2032	3.57-01 3 2032	4.00-01 3 2032	2.90+00 3 2032	7.94-02 3 2032	8.87+00 3	0000	3.79+01 2 2000	8.90-05 3 2042	4.28-03 3 2042	1.00-01 3 2042	2007	1.00+00 2 2081	3.82+09 2 2081	0000	0000	3.50+04 2 2073	35
3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.00-02 3 2032	8.16-03 3 2032	3.05-03 3 2032	9.18-01 3	0000	1.60-01 3 2071	0000	0000	0000	2000	9.90-01 2 2002	4.07+10 2 2002	0000	0000	[illegible].51+05 3 2077	36
3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.00-02 3 2032	8.16-03 3 2032	3.35-03 3 2032	9.18-01 3	0000	1.60-01 3 2071	0000	0000	0000	2000	9.00-01 2 2002	4.07+10 2 2002	0000	0000	1.52+05 3 2000	37
3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032	1.60+00 3 2032	1.00+00 3 2032	1.00-01 3 2032	1.00+01 3	0000	1.66-01 3 2071	0000	0000	0000	2000	1.00+00 2 2003	2.57+10 2 2003	0000	0000	2.29+05 2 2074	38
6.00-01 3 2032	1.07+01 3 2032	1.37+00 3 2032	1.67+00 3 2032	1.16+01 3 2032	3.06-01 3 2032	3.63+01 3	0000	3.63+02 3 2060	0000	0000	0000	2000	0000	1.41+10 3 2020	0000	0000	8.14+04 2 2075	39
1.20+00 3 2032	3.84+00 3 2032	3.33+00 3 2032	2.98+00 3 2032	3.50+00 3 2032	5.00-01 3 2032	1.52+01 3	0000	1.00+01 3 2000	0000	0000	0000	2048	0000	1.46+10 2 2030	0000	0000	9.80+04 3 2078	40
																		41
0000	0000	0000	3.00+01 3 2030	0000	0000	3.00+01 3	0000	1.73-01 2 2080	0003	0000	0000	2000	9.00-01 2 2000	0.00+00 2 0007	0000	0000	0000	42
																		43
0000	0000	0000	4.00+01 3 2030	0000	0000	4.00+01 3	0000	0000	0000	0000	0000	2000	9.90-01 2 2000	0.00+00 2 0007	1.10+05 4 2000	0000	0000	44
																		45
																		46
																		47
																		48
																		49
																		50

TABLE 13. ENVIRONMENTAL IMPACTS, EFFICIENCY AND COST FOR UNCONTROLLED NATIONAL OIL SUPPLY

2000

ENTRIES IN THE TABLE ARE BASED ON AN ENERGY INPUT TO EACH PROCESS OF 1.0E12 BTU/YR. ADDITIONALLY, THE BBL/YR OF CRUDE OR REFINED PETROLEUM EQUIVALENT TO 1.0E12 BTU/YR WERE DETERMINED ON THE BASIS OF THE HEATING VALUE MOST CLOSELY REPRESENTATIVE OF THAT CRUDE OR REFINED PETROLEUM (0005,38). THE CRUDE OIL SUPPLY OF THE U.S. COMES FROM THE FOLLOWING AREAS-DOMESTIC ONSHORE PRODUCTION 69.8P,DOMESTIC OFFSHORE PRODUCTION 15.1P AND FOREIGN IMPORTS 15.1P BASED ON DATA FROM (2005,8/9). THE COMPOSITE SULFUR CONTENT OF THE ENTIRE SUPPLY IS 0.79P BASED ON THE DISTRIBUTION ABOVE AND THE SULFUR CONTENT OF DIFFERENT DOMESTIC AND FOREIGN CRUDES FROM (2018,59) AND (2019,1/13). 1.0E12 BTU OF CRUDE OIL IS EQUIVALENT TO 178,000 BBL.

2001

BASED ON 1963 DATA, 587777 PRODUCING OIL WELLS (0010,47),INCLUDING 2321 OFFSHORE WELLS (0010,53),TOTAL PRODUCTION OF 2.75E9 BBLS (0010,70) INCLUDING 1.75E8 BBLS FROM OFFSHORE WELLS (0010,53). ON THIS BASIS AV PRODUCTIONS PER WELL ARE 4.4E3 BBL ONSHORE AND 7.54E4 OFFSHORE,ANNUALLY. ASSUMING A LAND REQUIREMENT OF 1/4 AC/ONSHORE WELL AND 1/2 AC/OFFSHORE WELL, THE IMPACTS ARE 3.03 AC-YR/1.0E12 BTU IN ONSHORE AND .354 AC-YR/1.0E12 BTU IN OFFSHORE. IF OIL PRODUCTION FROM WELLS PRODUCING OIL AND GAS IS CONSIDERED THE LAND IMPACTS SHOULD BE CHANGED TO 2.35 AC-YR/1.0E12 BTU IN ONSHORE AND .274 AC-YR/1.0E12 BTU IN OFFSHORE. THESE VALUES ARE BASED ON 1963 DATA, TOTAL GAS PRODUCTION FROM OIL WELLS OF 4.367E12 CF (0010,108) INCLUDING 2.79E11 CF FROM OFFSHORE OIL WELLS (0010,63). ON THIS BASIS AV PRODUCTION OF GAS PER OIL WELL IS 6.98E6 CF GAS FOR ONSHORE AND 1.20E8 CF GAS FOR OFFSHORE. ON THIS BASIS APPROXIMATELY 2.92E11 BTU/YR OF GAS ARE PRODUCED IN ADDITION TO THE 1.0E12 BTU/YR OF OIL FOR ONSHORE WELLS AND 2.93E11 BTU/YR OF GAS ARE PRODUCED IN ADDITION TO THE 1.0E12 BTU/YR OF OIL FROM OFFSHORE WELLS. THE ALLOCATION OF ACREAGE TO OIL PRODUCTION IS BASED ON THE OIL FRACTION OF THE TOTAL PRODUCTION/WELL EXPRESSED IN BTU EQUIVALENTS. USING 1031 BTU/SCF GAS (0005,38), THE OIL FRACTIONS ARE .774 FOR ONSHORE AND .773 FOR OFFSHORE. AT 1/4 AC/ONSHORE WELL AND 1/2 AC/OFFSHORE WELL,THE IMPACTS GIVEN ABOVE ARE OBTAINED.

2002

LAND IMPACT FOR PIPELINE TRANSPORT OF CRUDE OIL IS BASED ON 1971 TOTAL CRUDE OIL TRUNK AND GATHERING LINE MILEAGE OF 146200 MI (2001,2) AND TOTAL CRUDE OIL TRANSPORTED BY PIPELINE IN 1971 OF 3.095E9 BBL (0005,14). ASSUMING AN AV PIPELINE RIGHT-OF-WAY OF 62.5 FT (2002,14), ABOUT 63.6 AC ARE AFFECTED PER 1.0E12 BTU SHIPPED.

2003

APPROXIMATELY 0.006P(VOL) OF THE OIL MOVED BY PIPELINE IS LOST IN LEAKAGE(0012,71).ASSUMING THAT 5P EVENTUALLY SEEPS INTO WATER BODIES, 0.08TONS/YR ARE LOST. BASED ON 178000 BBL/YR CRUDE.

2004

THE OIL EMITTED TO WATERBODIES FROM ONSHORE PRODUCTION IS THAT OIL RELEASED BY THE INCOMPLETE SEPARATION OF BRINE AND OIL AT THE WELL. BASED ON BRINE PRODUCTION OF 2.7 BBL PER BBL CRUDE OIL AND 12P OF THE BRINE DISPOSED OF IN NONPOTABLE OR SALINE WATER BODIES(2003,147)AND 0.005P OIL CONTENT IN THE BRINE(2003,102). THE BRINE DISCHARGE ITSELF IS NOT CONSIDERED A POLLUTANT TO THE RECEIVING WATERBODY.

2005

ELECTROSTATIC DESALTING

BBL FEED EQUIVALENT TO 1.0E12 BTU IS 178000(0005,38 AND FOOTNOTE 2000). ELECTRIC ENERGY REQD. IS .006 KWH/BBL(2006,189)

** WATER POLLUTANTS **

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FTN. 2006

THERMAL-GALLONS COOLING WATER/BBL FEED IS 0.0 AND NO DELTA T 699
(2006,189) 799
ORGANICS INCLUDE OIL AT 0.012 LB/BBL FEED (2011, 899
11), PHENOL AT 0.00005 LB/BBL FEED(2009,A-4/A-5) 999
OTHER DISSOLVED SOLIDS INCLUDE SALT AT 0.097 LB/BBL FEED(2008,1099
104/113), HYDROGEN SULFIDE AT 0.008 LB/BBL FEED(2011,11) AND 1199
AMMONIA AT 0.009 LB/BBL FEED(2011,11) 1299
BOD LOAD IS 0.003 LB/BBL FEED(2011,11) 1399
COD LOAD IS 0.032 LB/BBL FEED(2011,11) 1499
TDS LOAD IS 0.25 LB/BBL FEED (2011,11) 1599
** AIR POLLUTANTS ** 1699
ELECTROSTATIC DESALTING IS CONSIDERED AN INTEGRAL PART OF THE 1799
ATMOSPHERIC/VACUUM DISTILLATION PROCESS AND,AS SUCH, ITS AIR 1899
EMISSIONS ARE INCLUDED WITH THOSE OF THE DISTILLATION PROCESS 1999
2006 199
ATMOSPHERIC/VACUUM DISTILLATION 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 178000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 290 AND DELTA T IS 699
35F(2006,217) 799
ORGANICS INCLUDE OIL AT 0.017 LB/BBL FEED (2011, 899
11), PHENOL AT 0.001 LB/BBL FEED(2009,A-4/A-5) 999
OTHER DISSOLVED SOLIDS INCLUDE HYDROGEN SULFIDE AT 0.001 LB/ 1099
BBL(2011,11) 1199
BOD LOAD IS 0.0002 LB/BBL FEED(2011,11) 1299
COD LOAD IS 0.005 LB/BBL FEED(2011,11) 1399
TDS LOAD IS 0.35 LB/BBL FEED(2011,11) 1499
** AIR POLLUTANTS ** 1599
THE AIR POLLUTANTS FOR THIS PROCESS ALSO INCLUDE THOSE FOR THE1699
ELECTROSTATIC DESALTER. 1799
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1899
HEATERS, BLOWDOWN SYSTEMS,PIPELINE VALVES AND FLANGES,VESSEL 1999
RELIEF VALVES, PUMP AND COMPRESSOR SEALS,VACUUM JETS AND PRO- 2099
CESS DRAINS. AIR POLLUTANT EMISSION FACTORS FROM (0002,1-9, 2199
9-3/9-4). NATURAL GAS WAS ASSUMED TO BE THE FUEL USED IN THE 2299
BOILERS AND PROCESS HEATERS. 2399
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 1.759E7 2499
BASED ON (2006,217) AND 1031 BTU/SCF(0005,38). 2599
SCF FUEL REQUIRED FOR THE PRODUCTION OF STEAM IS 3.10E6 2699
BASED ON (2006,217),FUEL EFFICIENCY OF 85% AND 1031 BTU/SCF 2799
(0005,38) ALSO ELECTRIC AT 0.4 KWH/BBL(2006,217) 2899
WASTEWATER FLOW FOR ELECTROSTATIC DESALTER IS 2.1 GAL/BBL 2999
FEED AND FOR DISTILLATION 26.0 GAL/BBL FEED (2011,11). 3099
** AIR EMISSIONS (TONS/YR) ** 3199

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				3299
				3399
PARTICULATES	1.76E-01	3.10E-02	-	3499
NOX	2.02E+00	3.56E-01	-	3599
SOX	5.28E-03	9.30E-04	-	3699
HC	2.64E-01	4.65E-02	2.79E+01	3799
CO	3.52E-03	6.20E-04	-	3899
NH3	0.00E+00	0.00E+00	-	3999
OTHER ORGANICS	8.80E-02	1.56E-02	-	4099

BASED ON (2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 4199
100000 BPSD, THE PROCESSING CAPACITY OF THE ELECTROSTATIC 4299
DESALTER AND ATMOSPHERIC/VACUUM DISTILLATION UNIT IS 100000 4399
BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 4499
306700 BPSD(THAT IS, THE SUM OF THE CAPACITIES OF THE INDIVID-4599
UAL PROCESSES). THUS, THE FRACTION OF TOTAL PROCESSING CAPA- 4699
CITY ATTRIBUTABLE TO THE DESALTING AND DISTILLATION PROCESSES 4799

IS 0.326C5. USED TO OBTAIN TOTAL OTHER REFINERY EMISSIONS AT 4899
PROCESS LEVEL. 4999

2007 199

CATALYTIC CRACKING AND CATALYST REGENERATION 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 176000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATEF POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 475 AND DELTA T IS 699
25F(2006,131/138) 799
ORGANICS INCLUDE OIL AT .10 LB/BBL FEED (2011,11) 899
AND PHENOL AT 0.005 LB/BBL(2009,A-4/A-5) 999
OTHER DISSOLVED SOLIDS INCLUDE SULFIDES(AS H2S) AT 0.036 LB/ 1099
BBL FEED AND NITRATES(AS NH3) AT 0.04 LB/BBL FEED(2011,11) 1199
BOD LOAD IS 0.015 LB/BBL FEED (2011,11) 1299
CCD LOAD IS 0.018 LB/BBL FEED (2011,11) 1399
TDS LOAD IS 0.09 LB/BBL FEED (2011,11) 1499
** AIR POLLUTANTS ** 1599
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1699
HEATERS,BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES, VESSEL 1799
RELIEF VALVES, PUMP AND COMPRESSOR SEALS,PROCESS DRAINS AND, 1899
FOR THIS PROCESS ONLY, THE CONVERSION OPERATION. AIR POLLUTANT 1999
EMISSION FACTORS FROM(0002,1-9,9-3/9-4)EXCEPT FOR CONVERSION 2099
SOX EMISSIONS WHICH ARE DETERMINED AS FOLLOWS- 3.2P OF TOTAL 2199
SULFUR IN CRUDE IS ATTRIBUTABLE TO REFINERY CAT CRACKER SOX 2299
EMISSIONS (2024) AND NATIONAL AVERAGE CRUDE HAS .79P SULFUR 2399
(FOOTNOTE 2000). THESE REFINERY CAT CRACKER CONVERSION SOX 2499
EMISSIONS ARE THEN OBTAINED FOR 1.0E12 BTU INPUT TO CAT 2599
CRACKER BY MULTIPLYING BY RATIO OF BBL OF FEED EQUIVALENT 2699
TO 1.0E12 BTU TO BBL OF CRUDE EQUIVALENT TO 1.0E12 BTU AND 2799
THEN MULTIPLIED BY RATIO OF BBL OF CRUDE PROCESSED/DAY IN THE 2899
REFINERY TO BBL OF FEED/DAY TO CAT CRACKER FROM(2009,FIG.3). 2999
NATURAL GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS 3099
AND PROCESS HEATERS. SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU 3199
FEED IS 2.416E7 BASED ON(2006,131/8)AND 1031 BTU/SCF(0005,38) 3299
SCF FUEL REQUIRED FOR THE PRODUCTICN OF STEAM IS 6.50E6 3399
BASED ON(2006,137/8)FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF 3499
(0005,38) ELECTRIC AT 1.04 KWH/BBL(2006,131/138) 3599
WASTEWATER FLOW FOR THE CAT. CRACKING AND REGEN. PROCESS IS 3699
15.0 GAL/BBL FEED(2011,11) 3799
** AIR EMISSIONS (TONS/YR) ** 3899

COMPONENT	CONVERSION	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
					3999
PARTICULATES	5.37E+00	2.42E-01	6.50E-02	-	4099
NOX	5.54E+00	2.78E+00	7.48E-01	-	4199
SOX	2.63E+01	7.25E-03	1.95E-03	-	4299
HC	1.94E+01	3.63E-01	9.75E-02	1.73E+01	4399
CO	1.21E+03	4.83E-03	1.30E-03	-	4499
NH3	4.75E+00	0.00E+00	0.00E+00	-	4599
OTHER ORGANICS	1.67E+00	1.21E-01	3.73E-02	-	4699
					4799

BASED ON (2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 4899
100000 BPSD, THE PROCESSING CAPACITY OF THE CATALYTIC CRACK- 4999
ING AND CATALYST REGENERATION IS 50000 BPSD. THE TOTAL PRO- 5099
CESSING CAPACITY OF THE REFINERY IS 306700 BPSD(THAT IS, THE 5199
SUM OF THE CAPACITIES OF THE INDIVIDUAL PROCESSES). THUS,THE 5299
FRACTION OF THE TOTAL PROCESSING CAPACITY ATTRIBUTABLE TO 5399
THE CAT. CRACKING PROCESS IS 0.16303 AND IS USED TO OBTAIN HC 5499
EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 5599

2008 199

CATALYTIC REFORMING 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 190000(0005,38 AND FOOT- 399
NOTE 2000) 499

FTN. 2009

** WATER POLLUTANTS **
THERMAL-GALLONS COOLING WATER/BBL FEED IS 150 AND DELTA T IS 25F(2006,117/118)
ORGANICS INCLUDE OIL AT .05 LB/BBL FEED (2011,11)
AND PHENOL AT 0.0007 LB/BBL FEED(2009,A-4/A-5)
OTHER DISSOLVED SOLIDS INCLUDE SULFIDES(AS H2S) AT 0.001 LB/BBL FEED(2011,11)
COD LOAD IS 0.04 LB/BBL FEED(2011,11)
TDS LOAD IS 0.125 LB/BBL FEED(2011,11)
** AIR POLLUTANTS **
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL RELIEF VALVES, PUMP AND COMPRESSOR SEALS,AND PROCESS DRAINS. AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4). NATURAL GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND PROCESS HEATERS.
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 3.323E7
BASED ON (2006,117/118) AND 1031 BTU/SCF(0005,38)
NO STEAM REQUIRED . ELECTRIC AT 4.75 KWH/BBL
WASTEWATER FLOW FOR THE CAT. REFORMING PROCESS IS 6.0 GAL/BBL FEED(2011,11)
** AIR EMISSIONS (TONS/YR) **

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
PARTICULATES	3.32E-01	-	-
NOX	3.82E+00	-	-
SOX	9.97E-03	-	-
HC	4.98E-01	-	1.43E+01
CO	6.65E-03	-	-
NH3	0.00E+00	-	-
OTHER ORGANICS	1.56E-01	-	-

BASED ON (2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 100000 BPSD, THE PROCESSING CAPACITY OF THE CATALYTIC REFORMING PROCESS IS 23000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 306700 BPSD(THAT IS, THE SUM OF THE CAPACITIES OF THE INDIVIDUAL PROCESSES). THUS, THE FRACTION OF THE TOTAL PROCESSING CAPACITY ATTRIBUTABLE TO THE CATALYTIC REFORMER IS 0.07499 AND IS USED TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL.

2009

DISTILLATE HYDROTREATING
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 172000(0005,38 AND FOOTNOTE 2000)
** WATER POLLUTANTS **
THERMAL-GALLONS COOLING WATER/BBL FEED IS 150 AND DELTA T IS 25F(2006,164)
ORGANICS INCLUDE PHENOL AT 0.00001 LB/BBL FEED (2009,A-4/A-5)
OTHER DISSOLVED SOLIDS INCLUDE SULFIDES(AS H2S) AT 0.002 LB/BBL FEED AND NITRATES(AS NH3) AT 0.03 LB/BBL FEED(2011,11)
BOD LOAD IS 0.01 LB/BBL FEED(2011,11)
COD LOAD IS 0.05 LB/BBL FEED(2011,11)
TDS LOAD IS 0.035 LB/BBL FEED(2011,11)
** AIR POLLUTANTS **
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES, VESSEL RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND PROCESS HEATERS.
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 1.020E06

BASED ON(2006,164) AND 1031 BTU/SCF(0005,38) 2399
SCF FUEL REQUIRED FOR THE PRODUCTION OF STEAM IS 4.35E05 2499
BASED ON(2006,164), FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF 2599
(0005,38) ELECTRIC AT 0.05 KWH/BBL 2699
WASTEWATER FLOW FOR THE DISTILLATE HYDROTREATER IS 8.0 GAL/ 2799
BBL FEED(2009,A-4/A-5) 2899
** AIR EMISSIONS (TONS/YR) ** 2999

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
PARTICULATES	1.02E-02	4.35E-03	-	3099
NOX	1.17E-01	5.00E-02	-	3199
SOX	3.06E-04	1.31E-04	-	3299
HC	1.53E-02	6.53E-03	1.38E+01	3399
CO	2.04E-04	8.70E-05	-	3499
NH3	0.00E+00	0.00E+00	-	3599
OTHER ORGANICS	5.10E-03	2.17E-03	-	3699

BASED ON(2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 3799
100000 BPSD, THE PROCESSING CAPACITY OF THE DISTILLATE 3899
HYDROTREATER IS 40000 BPSD. THE TOTAL PROCESSING CAPACITY OF 3999
THE REFINERY IS 306700 BPSD(THAT IS, THE SUM OF THE CAPACIT- 4099
IES OF THE INDIVIDUAL PROCESSES). THUS, THE FRACTION OF THE 4199
TOTAL PROCESSING CAPACITY ATTRIBUTABLE TO THE DISTILLATE 4299
HYDROTREATER IS 0.13042 AND IS USED TO OBTAIN HC EMISSION FOR 4399
OTHER SOURCES AT THE PROCESS LEVEL. 4499

2010 199

DELAYED COKING 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 159000(0005,38 AND FOOT- 399
NOTE 2000). 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 520 AND DELTA T IS 699
25F(2005,181) 799
ORGANICS INCLUDE OIL AT 0.006 LB/BBL FEED (2011, 899
11) AND PHENOL AT 0.0002 LB/BBL FEED(2009,A-4/A-5) 999
COD LOAD IS 0.032 LB/BBL FEED(2011,11) 1099
TDS LOAD IS 0.030 LB/BBL FEED(2011,11) 1199
** AIR POLLUTANTS ** 1299
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1399
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES, VESSEL 1499
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1599
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL 1699
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND PROCESS 1799
HEATERS. 1899
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 4.085E07 1999
BASED ON(2005,181) AND 1031 BTU/SCF(0005,38) 2099
SCF FUEL REQUIRED FOR THE PRODUCTION OF STEAM IS 1.11E07 2199
BASED ON(2005,181), FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF 2299
(0005,38). ELECTRIC AT 5 KWH/BBL. 2399
WASTEWATER FLOW FOR THE DELAYED COKER IS 1.0 GAL/BBL FEED 2499
(2011,11) 2599
** AIR EMISSIONS (TONS/YR) ** 2699

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
PARTICULATES	4.09E-01	1.11E-01	-	2799
NOX	4.70E+00	1.27E+00	-	2899
SOX	1.23E-02	3.33E-03	-	2999
HC	6.14E-01	1.67E-01	1.00E+01	3099
CO	8.17E-03	2.22E-03	-	3199
NH3	0.00E+00	0.00E+00	-	3299
OTHER ORGANICS	2.04E-01	5.56E-02	-	3399

BASED ON(2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 3499
100000 BPSD, THE PROCESSING CAPACITY OF THE DELAYED COKER IS 3599

10000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 3899
306700 BPSD(THAT IS, THE SUM OF THE CAPACITIES OF THE INDI- 3999
VIDUAL PROCESSES). THUS, THE FRACTION OF THE TOTAL PROCESSING4099
CAPACITY ATTRIBUTABLE TO THE DELAYED COKER IS 0.03261 AND IS 4199
USED TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS 4299
LEVEL. 4399

2011 199

DISTILLATE HYDROCRACKING 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 172000(0005,38 AND FOOT- 399
NOTE 2000). 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 250 AND DELTA T IS 699
40F(2006,146) 799
OTHER DISSOLVED SOLIDS INCLUDE SULFIDES(AS H2S) AT 0.002 LB/ 899
BBL FEED(2011,11) 999
BOD LOAD IS 0.002 LB/BBL FEED(2011,11) 1099
CCD LOAD IS 0.045 LB/BBL FEED(2011,11) 1199
TDS LOAD IS 0.002 LB/BBL FEED(2011,11) 1299
** AIR POLLUTANTS ** 1399
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1499
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES, VESSEL1599
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1699
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL 1799
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND PROCESS1899
HEATERS. 1999
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 2.719E07 2099
BASED ON(2006,146) AND 1031 BTU/SCF(0005,38). 2199
NO STEAM REQUIRED(2006,146) ELECTRIC AT 10 KWH/BBL. 2299
WASTEWATER FLOW FOR THE DISTILLATE HYDROCRACKER IS 5.0 GAL/ 2399
BBL FEED(2009,A-4/A-5) 2499
** AIR EMISSIONS (TONS/YR) ** 2599

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				2699
				2799
PARTICULATES	2.72E-01	-		2899
NOX	3.13E+00	-		2999
SOX	8.16E-03	-		3099
HC	4.08E-01	-	1.26E+01	3199
CO	5.44E-03	-		3299
NH3	0.00E+00	-		3399
OTHER ORGANICS	1.36E-01	-		3499

BASED ON(2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 3599
100000 BPSD, THE PROCESSING CAPACITY OF THE DISTILLATE 3699
HYDROCRACKER IS 14000 BPSD. THE TOTAL PROCESSING CAPACITY OF 3799
THE REFINERY IS 306700 BPSD(THAT IS, THE SUM OF THE CAPACIT- 3899
IES OF THE INDIVIDUAL PROCESSES). THUS, THE FRACTION OF THE 3999
TOTAL PROCESSING CAPACITY ATTRIBUTABLE TO THE HYDROCRACKER 4099
IS 0.04565 AND IS USED TO OBTAIN HC EMISSION FOR OTHER 4199
SOURCES AT THE PROCESS LEVEL. 4299

2012 199

ISOMERIZATION 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 216000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 50 AND DELTA T IS 699
25F(2006,125) 799
** AIR POLLUTANTS ** 899
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 999
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES, VESSEL1099
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1199
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL 1299
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND PROCESS1399

HEATERS.
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 1.067E07
BASED ON(2006,125) AND 1031 BTU/SCF(0005,38)
SCF FUEL REQUIRED FOR THE PRODUCTION OF STEAM IS 8.76E06
BASED ON(2006,125),FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF
(0005,38) ELECTRIC AT 1.5 KWH/BBL
** AIR EMISSIONS (TONS/YR) **

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
PARTICULATES	1.07E-01	8.76E-02	
NOX	1.23E+00	1.01E+01	
SOX	3.20E-03	2.63E-03	
HC	1.61E-01	1.31E-01	1.31E+01
CO	2.13E-03	1.75E-03	
NH3	0.00E+00	0.00E+00	
OTHER ORGANICS	5.34E-02	4.38E-02	

BASED ON(2009,FIG.3),FOR A REFINERY WITH A CAPACITY OF
100000 BPSD, THE PROCESSING CAPACITY OF THE ISOMERIZATION
UNIT IS 1000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE
REFINERY IS 306700 BPSD(THAT IS, THE SUM OF THE CAPACITIES
OF THE INDIVIDUAL PROCESSES). THUS, THE FRACTION OF THE
TOTAL PROCESSING CAPACITY ATTRIBUTABLE TO THE ISOMERIZATION
UNIT IS 0.00326 AND IS USED TO OBTAIN HC EMISSION FOR OTHER
SOURCES AT THE PROCESS LEVEL.

2013

H2SO4 ALKYLATION
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 237000(0005,38 AND FOOT-
NOTE 200C). ELECTRIC AT 2 KWH/BBL.
** WATER POLLUTANTS **
THERMAL-GALLONS COOLING WATER/BBL FEED IS 1500 AND DELTA T IS
35F(2006,127)
ORGANICS INCLUDE PHENOL AT 0.0001 LB/BBL FEED
(2009,A-4/A-5)
OTHER DISSOLVED SOLIDS INCLUDE SULFIDES(AS H2S) AT 0.02 LB/BBL
(2009,A-4/A-5) AND NITRATES(AS NH3) AT 0.00 LB/BBL(2011,11)
BOD LOAD IS 0.001 LB/BBL FEED(2011,11)
COD LOAD IS 0.01 LB/BBL FEED(2011,11)
TDS LOAD IS 0.30 LB/BBL FEED(2011,11)
** AIR POLLUTANTS **
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES, VESSEL
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS.
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL
GAS WAS ASSUMED TO BE THE FUEL USED IN THE HEATERS AND BOILERS
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 0(2006,127)
SCF FUEL REQUIRED FOR STEAM PRODUCTION IS 8.25E07. BASED ON
(2006,127), FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF(0005,38)
** AIR EMISSIONS (TONS/YR) **

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
PARTICULATES	-	8.25E-01	
NOX	-	9.50E+00	
SOX	-	2.48E-03	
HC	-	1.24E+00	4.99E+01
CO	-	1.65E-02	
NH3	-	0.00E+00	
OTHER ORGANICS	-	4.13E-01	

WASTEWATER FLOW FOR THE ALKYLATION UNIT IS 60 GAL/BBL FEED
(2011,11)
BASED ON(2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF
100000 BPSD, THE PROCESSING CAPACITY OF THE ALKYLATION UNIT

FTN. 2014-2015

IS 6000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY 3899
IS 306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS 3999
CAPACITIES). THUS, THE FRACTION OF THE TOTAL PROCESSING CAPA-4099
CITY ATTRIBUTABLE TO ALKYLATION IS 0.01956 AND IS USED TO 4199
OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 4299

2014 199

AROMATICS EXTRACTION(RECOVERY) 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 200000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 1000 AND DELTA T IS 699
25F(2006,185) 799
NO OTHER WATER POLLUTANT INFORMATION AVAILABLE 899
** AIR POLLUTANTS ** 999
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1099
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL 1199
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1299
AIR POLLUTANT EMISSION FACTORS FROM(0002,9-3/9-4). NO DATA 1399
ON FUEL OR STEAM REQUIREMENTS AVAILABLE. 1499
** AIR EMISSIONS (TONS/YR) ** 1599
NO BOILER OR HEATER EMISSIONS. EMISSIONS FOR OTHER SOURCES 1699
ONLY. ONLY COMPONENT IS HC 1799
HC EMISSIONS - 1.61E+01 1899
WASTEWATER FLOW IS 8.0 GAL/BBL FEED(2009,A-4/A-5) 1999
BASED ON(2009,FIG.3), FOR A REFINERY WITH A CAPACITY OF 2099
100000 BPSD, THE PROCESSING CAPACITY OF THE AROMATICS UNIT 2199
IS 2500 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY 2299
IS 306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS 2399
CAPACITIES). THUS, THE FRACTION OF THE TOTAL PROCESSING 2499
CAPACITY ATTRIBUTABLE TO THE AROMATICS UNIT IS 0.00816 AND IS2599
USED TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS 2699
LEVEL. 2799

2015 199

FURFURAL REFINING 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 165000(0005,38 AND FOOT- 399
NOTE 2000) ELECTRIC AT 1.0KWH/BBL(2006,191) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 1000 AND DELTA T IS 699
25F(2006,191) 799
ORGANICS INCLUDE PHENOL AT .003 LB/BBL (2009,A-4, 899
A-5) 999
** AIR POLLUTANTS ** 1099
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1199
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL 1299
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1399
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL 1499
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND HEATERS1599
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 4.65E07. 1699
BASED ON(2006,191) AND 1031 BTU/SCF(0005,38) 1799
SCF FUEL REQUIRED FOR STEAM BOILERS IS 7.65E06. BASED ON 1899
(2006,191), FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF(0005,38) 1999
** AIR EMISSIONS (TONS/YR) ** 2099

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				2199
				2299
PARTICULATES	4.65E-01	7.65E-02		2399
NOX	5.35E+00	8.80E-01		2499
SOX	1.39E-02	2.30E-03		2599
HC	6.98E-01	1.15E-01	1.33E+01	2699
CO	9.29E-02	1.53E-03		2799
NH3	0.00E+00	0.00E+00		2899
OTHER ORGANICS	2.33E-01	3.83E-02		2999

WASTEWATER FLOW FOR THE FURFURAL UNIT IS 8.0 GAL/BBL FEED
(2009,A-4/A-5)
BASED ON(2009,FIG.3), FOR A REFINERY OF 100000 BPSD CAPACITY
THE PROCESSING CAPACITY OF THE FURFURAL REFINING UNIT IS 3500
BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS
306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS CAPA-
CITIES). THUS, THE FRACTION OF THE TOTAL PROCESSING CAPACITY
ATTRIBUTABLE TO THE FURFURAL UNIT IS 0.01141 AND IS USED TO
OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL.

2016

SOLVENT DEWAXING

BBL FEED EQUIVALENT TO 1.0E12 BTU IS 165000(0005,38 AND FOOT-
NOTE 2000) ELECTRIC AT 12 KWH/BBL(2006,200)
** WATER POLLUTANTS **
THERMAL-GALLONS COOLING WATER/BBL FEED IS 2300 AND DELTA T IS
25F(2006,200)
ORGANICS INCLUDE PHENOL AT 0.0015 LB/BBL FEED
(2009,A-4/A-5)
BOD LOAD IS 0.25 LB/BBL FEED(2009,A-4/A-5)
** AIR POLLUTANTS **
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS.
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND HEATERS
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 4.73E07.
BASED ON(2006,200) AND 1031 BTU/SCF(0005,38)
SCF FUEL REQUIRED FOR STEAM PRODUCTION IS 7.65E06. BASED ON
(2006,200), FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF(0005,38)
** AIR EMISSIONS (TONS/YR) **

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
PARTICULATES	4.73E-01	7.65E-02	
NOX	5.44E+00	8.80E-01	
SOX	1.42E-02	2.30E-03	
HC	7.10E-01	1.15E-01	1.82E+01
CO	9.46E-03	1.53E-03	
NH3	0.00E+00	0.00E+00	
OTHER ORGANICS	2.36E-01	3.83E-02	

WASTEWATER FLOW FOR THE DEWAXING UNIT IS 20 GAL/BBL FEED
(2009,A-4/A-5)
BASED ON(2009,FIG.3), FOR A REFINERY OF 100000 BPSD CAPACI-
TY, THE PROCESSING CAPACITY OF THE SOLVENT DEWAXING UNIT IS
4000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY
IS 306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS
CAPACITIES). THUS, THE FRACTION OF THE TOTAL PROCESSING
CAPACITY ATTRIBUTABLE TO THE DEWAXING UNIT IS 0.01304 AND IS
USED TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS
LEVEL.

2017

PROPANE DEASPHALTING

BBL OF FEED EQUIVALENT TO 1.0E12 BTU IS 159000(0005,38 AND
FOOTNOTE 2000) ELECTRIC AT 2.7 KWH/BBL (2006,195).
** WATER POLLUTANTS **
THERMAL-GALLONS COOLING WATER/BBL FEED IS 1500 AND DELTA T IS
25F(2006,195)
** AIR POLLUTANTS **
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS.
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL

GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND HEATERS 1399
SCF FUEL REQUIRED TO PROCESS 1.0E12 BTU FEED IS 3.33E07 1499
BASED ON(2006,195) AND 1031 BTU/SCF(0005,38) 1599
SCF FUEL REQUIRED FOR STEAM PRODUCTION IS 6.75E07. BASED ON 1699
(2006,195),FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF(0005,38) 1799
** AIR EMISSIONS (TONS/YR) ** 1899

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				1999
PARTICULATES	3.31E-01	6.75E-01		2099
NOX	3.83E+00	7.75E+00		2199
SOX	1.00E-02	2.03E-02		2299
HC	5.00E-01	1.01E+00	9.62E+00	2399
CO	6.66E-03	1.35E-02		2499
NH3	0.00E+00	0.00E+00		2599
OTHER ORGANICS	1.67E-01	3.37E-01		2699

BASED ON(2009,FIG.3),FOR A REFINERY OF 100000 BPSD CAPACITY, 2799
THE PROCESSING CAPACITY OF THE PROPANE DEASPHALTING UNIT IS 2899
3000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 2999
306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS CAPA- 3099
CITIES).THUS, THE FRACTION OF THE TOTAL PROCESSING CAPACITY 3199
ATTRIBUTABLE TO THE DEASPHALTING UNIT IS 0.00978 AND IS USED 3299
TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 3399
2018 3499

SOUR GAS TREATING (LP-GAS) 199
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 249000(0005,38 AND FOOT- 299
NOTE 2000). 399
** WATER POLLUTANTS ** 499
THERMAL-GALLONS COOLING WATER/BBL FEED IS 15.5 AND DELTA T IS 599
20F(2005,257 AND 3002,4-88) 699
ORGANICS INCLUDE PHENOL AT 0.01 LB/BBL FEED 799
(2009,4-4/4-5). 899
BOD LOAD IS 0.05 LB/BBL FEED(2009,A-4/A-5) 999
** AIR POLLUTANTS ** 1099
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1199
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL 1299
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1399
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL 1499
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND PROCESS 1599
HEATERS. 1699
SCF FUEL REQUIRED FOR STEAM PRODUCTION IS 8.0E05. BASED ON 1799
(2005,257),FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF(0005,38) 1899
NO PROCESS HEATING REQUIRED. ELECTRIC AT 0.33 KWH/BBL 1999
** AIR EMISSIONS (TONS/YR) ** 2099

COMPONENT	STEAM BOILERS	PROCESS HEATERS	OTHER SOURCES	
				2199
PARTICULATES	8.00E-03	-		2299
NOX	9.20E-02	-		2399
SOX	2.40E-04	-		2499
HC	1.20E-02	-	4.00E+01	2599
CO	1.60E-04	-		2699
NH3	0.00E+00	-		2799
OTHER ORGANICS	4.00E-03	-		2899

WASTEWATER FLOW IS 40 GAL/BBL FEED(2009,A-4/A-5). BASED ON 2999
(2009,FIG.3) FOR A REFINERY WITH A CAPACITY OF 100000 BPSD,THE 3099
PROCESSING CAPACITY OF THE GAS TREATING UNIT IS 3000 BPSD.THE 3199
TOTAL PROCESSING CAPACITY OF THE REFINERY IS 306700 BPSD(THAT 3299
IS,THE SUM OF THE INDIVIDUAL PROCESS CAPACITIES).THUS THE 3399
FRACTION ATTRIBUTABLE TO GAS TREATING IS 0.00978 AND IS USED 3499
TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 3599
2019 3699

GASOLINE TREATING 3799

BBL FEED EQUIVALENT TO 1.0E12 BTU IS 200000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL- NO COOLING WATER REQUIRED(2006,193) 699
** AIR POLLUTANTS ** 799
NO STEAM OR PROCESS HEATING REQUIRED. ONLY EMISSIONS ARE HC 899
AND PROBABLY SOME ORGANIC DISULFIDES. 999
HC EMISSIONS(TONS/YR) 1.21E+01. EMISSION FACTORS FROM(0002, 1099
9-3/9-4) 1199
BASED ON (2009,FIG.2), FOR A REFINERY WITH A CAPACITY OF 1299
100000 BPSD, THE PROCESSING CAPACITY OF THE GASOLINE TREATING 1399
UNIT IS 42000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE 1499
REFINERY IS 306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL 1599
PROCESS CAPACITIES). THUS, THE FRACTION OF THE TOTAL PROCESS- 1699
ING CAPACITY ATTRIBUTABLE TO GASOLINE TREATING IS 0.13694 AND 1799
IS USED TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE 1899
PROCESS LEVEL. 1999

2020 199

LUBE OIL HYDROTREATING 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 165000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 810 AND DELTA T IS 699
25F(2006,156) 799
ORGANICS INCLUDE PHENOL AT 0.00001 LB/BBL FEED 899
(2009,A-4/A-5) 999
OTHER DISSOLVED SOLIDS INCLUDE SULFIDES(AS H2S) AT 0.002 LB/ 1099
BBL FEED AND NITRATES(AS NH3) AT 0.03 LB/BBL FEED (2011,11) 1199
BOD LOAD IS 0.01 LB/BBL FEED(2011,11) 1299
COD LOAD IS 0.05 LB/BBL FEED(2011,11) 1399
TDS LOAD IS 0.035 LB/BBL FEED(2011,11) 1499
** AIR POLLUTANTS ** 1599
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1699
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL 1799
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1899
AIR POLLUTANT EMISSION FACTORS FROM (0002,1-9,9-3/9-4).NATURAL 1999
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND HEATERS 2099
SCF GAS REQUIRED FOR HEATERS 2.495E07.BASED ON(2006,156)AND 2199
1031 BTU/SCF(0005,38) ELECTRIC AT 2.3 KWH/BBL 2299
SCF GAS REQUIRED FOR STEAM PRODUCTION 1.12E07. BASED ON(2006, 2399
156),FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF(0005,38). 2499
WASTEWATER FLOW IS 8.0 GAL/BBL FEED(2009,A-4/A-5) 2599
** AIR EMISSIONS (TONS/YR) ** 2699

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				2799
PARTICULATES	2.50E-01	1.12E-01	-	2899
NOX	2.88E+00	1.28E+00	-	2999
SOX	7.85E-03	3.36E-03	-	3099
HC	3.75E-01	1.68E-01	1.33E+01	3199
CO	4.99E-03	2.24E-03	-	3299
NH3	0.00E+00	0.00E+00	-	3399
OTHER ORGANICS	1.25E-01	5.60E-02	-	3499

BASED ON(2009,FIG.3),FOR A REFINERY WITH A CAPACITY OF 100000 3599
BPSD, THE PROCESSING CAPACITY OF THE LUBE OIL HYDROTREATER IS 3699
4000 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 3799
306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS CAPA- 3899
CITIES).THUS, THE FRACTION OF THE TOTAL PROCESSING CAPACITY 3999
ATTRIBUTABLE TO LUBE OIL HYDROTREATING IS 0.01304 AND IS USED 4099
TO OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 4199

2021 199

GREASE MANUFACTURE 299

FTN. 2022-2023

BBL FEED EQUIVALENT TO 1.0E12 BTU IS 165000(0005,38 AND FOOT- 399
NOTE 2000) 499
NO INFORMATION AVAILABLE REGARDING WATER POLLUTANTS. 599
** AIR POLLUTANTS ** 699
ONLY INFORMATION REGARDING HC AIR POLLUTANTS AVAILABLE FROM 799
(0002,9-3/9-4). HC EMISSIONS ARE 9.94+00 TONS/YR BASED ON 899
THE ALLOCATION PROCEDURE DESCRIBED BELOW. 999
BASED ON (2009,FIG.3) FOR A REFINERY WITH A CAPACITY OF 1099
100000 BPSD, THE PROCESSING CAPACITY OF THE GREASE PLANT IS 1199
200 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 1299
306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS CAPA- 1399
CITIES).THUS,THE FRACTION OF THE TOTAL PROCESSING CAPACITY 1499
ATTRIBUTABLE TO GREASE MANUFACTURE IS 0.00065 AND IS USED TO 1599
OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 1699
2022 199
WAX DEOILING,MIBK 299
BBL FEED EQUIVALENT TO 1.0E12 BTU IS 181000(0005,38 AND FOOT- 399
NOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/BBL FEED IS 2500 AND DELTA T IS 699
10F(2006,206) 799
NO OTHER WATER POLLUTANT INFORMATION AVAILABLE. 899
** AIR POLLUTANTS ** 999
THE AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND PROCESS 1099
HEATERS, BLOWDOWN SYSTEMS, PIPELINE VALVES AND FLANGES,VESSEL 1199
RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS DRAINS. 1299
AIR POLLUTANT EMISSION FACTORS FROM(0002,1-9,9-3/9-4).NATURAL 1399
GAS WAS ASSUMED TO BE THE FUEL USED IN THE BOILERS AND HEATERS1499
SCF GAS REQUIRED FOR HEATERS IS 5.26E07. BASED ON(2006,206) 1599
AND 1031BTU/SCF(0005,38) ELECTRIC AT 9 KWH/BBL 1699
SCF GAS REQUIRED FOR BOILERS IS 1.28E07. BASED ON(2006,206), 1799
FUEL EFFICIENCY OF 85P AND 1031 BTU/SCF (0005,38). 1899
** AIR EMISSIONS (TONS/YR) ** 1999

COMPONENT	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				2099
				2199
PARTICULATES	5.26E-01	1.28E-01	-	2299
NOX	6.05E+00	1.47E+00	-	2399
SOX	1.58E-02	3.85E-03	-	2499
HC	7.91E-01	1.93E-01	1.09E+01	2599
CO	1.05E-02	2.56E-03	-	2699
NH3	0.00E+00	0.00E+00	-	2799
OTHER ORGANICS	2.63E-01	6.41E-02	-	2899

BASED ON (2009,FIG.3) FOR A REFINERY WITH A CAPACITY OF 2999
100000 BPSD, THE PROCESSING CAPACITY OF THE DEOILING UNIT IS 3099
500 BPSD. THE TOTAL PROCESSING CAPACITY OF THE REFINERY IS 3199
306700 BPSD(THAT IS, THE SUM OF THE INDIVIDUAL PROCESS CAPA- 3299
CITIES). THUS, THE FRACTION OF THE TOTAL PROCESSING CAPACITY 3399
ATTRIBUTABLE TO THE DEOILING UNIT IS 0.00163 AND IS USED TO 3499
OBTAIN HC EMISSION FOR OTHER SOURCES AT THE PROCESS LEVEL. 3599
2023 199
HYDROGEN MANUFACTURE(STEAM REFORMING) 299
SCF OF NATURAL GAS FEED EQUIVALENT TO 1.0E12 BTU IS 9.69E08. 399
(0005,38 AND FOOTNOTE 2000) 499
** WATER POLLUTANTS ** 599
THERMAL-GALLONS COOLING WATER/MSCF H2 IS 650 AND DELTA T IS 699
25F(2005,270) 799
NO OTHER WATER POLLUTANT INFORMATION AVAILABLE. 899
** AIR POLLUTANTS ** 999
THE AIR POLLUTANT SOURCES INCLUDE STEAM REFORMER AND WASTE 1099
HEAT BOILER, BLOWDOWN SYSTEM, PIPELINE VALVES AND FLANGES, 1199
VESSEL RELIEF VALVES, PUMP AND COMPRESSOR SEALS AND PROCESS 1299

DRAINS. AIR POLLUTANT EMISSION FACTORS FROM (0002,1-9,9-3/9-4) 1399
NATURAL GAS WAS ASSUMED TO BE THE FUEL USED IN THE REFORMER 1499
AND BOILER. 1599
SCF FUEL REQUIRED IN REFORMER IS 4.947E08. BASED ON (2005, 1699
270) AND 1031 BTU/SCF (0005,38) ELECTRIC AT 0.4 KWH/1000SCF 1799
SCF FUEL REQUIRED IN WASTE HEAT BOILER IS 0.0. BOILER USES 1899
WASTE GASES FROM REFORMER (2005,270) 1999
** AIR EMISSIONS (TONS/YR) ** 2099

COMPONENT	STEAM REFORMER	WASTE HEAT BOILER	OTHER SOURCES	
				2199
PARTICULATES	4.45E+00	-	-	2299
NOX	5.67E+01	-	-	2399
SOX	1.49E-01	-	-	2499
HC	9.89E+00	-	-	2599
CO	9.89E-02	-	-	2699
NH3	0.00E+00	-	-	2799
OTHER ORGANICS	2.48E+00	-	-	2899

WITH A NATURAL GAS FEED OF 1.0E12 BTU/YR, THE HYDROGEN PLANT 2999
CAN MAKE 1.83E09 SCF H2/YR (2005,270). A 100000 BPSD REFINERY 3099
USES APPROXIMATELY 100MMSCFD H2. 3199
3299

2024 199

IMPORTED OIL TRANSPORT 299
THE FOLLOWING APPROACH WAS USED IN CALCULATING THE AIR 399
POLLUTANTS ASSOCIATED WITH IMPORTING OIL. 499
1. ALL IMPORTED OIL IS TRANSPORTED BY TANKER 599
2. TANKER SIZE IS IN THE 45000 DWT CLASS. BASED ON (2007,10-7) 699
THE TANKER CAPACITY IS 396000 BBLS, SPEED IS 16 KNOTS, 799
UNLOADING CAPACITY IS 20000 BPH, UNLOADING TIME IS 19.8 HRS 899
3. ONE-WAY MILEAGE IS 10000 NAUTICAL MILES. THIS IS BASED ON 999
THE WEIGHTED AVERAGE ROUNDTRIP MILEAGE FOR CRUDE OIL IMPORT 1099
(0005,9) 1199
4. EMISSION FACTORS FOR STEAMSHIPS UNDERWAY AND IN-BERTH FROM 1299
(0002,3-11) 1399
5. FUEL OIL FOR POWERING SHIP CONTAINS 1P SULFUR 1499
6. IT WAS ASSUMED THAT ONLY THOSE EMISSIONS ASSOCIATED WITH 50 1599
MILES OF TRAVEL (100 MILES FOR ROUNDTRIP) WITHIN THE COASTAL 1699
WATERS OF THE CONTINENTAL U.S. WOULD HAVE ANY ENVIRONMENTAL 1799
IMPACTS. 1899
7. BASED UPON THE UNLOADING TIME OF 19.8 HRS, IT WAS ASSUMED 1999
THAT APPROXIMATELY 48 HRS WERE SPENT IN-BERTH. HOWEVER, 2099
THIS IS FOR UNLOADING 396000 BBL OIL. TO UNLOAD 178000 2199
BBL OIL (EQUIVALENT TO 1.0E12 BTU) APPROXIMATELY 24 HRS 2299
ARE SPENT IN-BERTH 2399
8. IT WAS ASSUMED THAT TWO DIESEL-POWERED TUGBOATS WOULD BE 2499
REQUIRED TO MANEUVER THE TANKER INTO PLACE. IT WAS ALSO 2599
ASSUMED THAT A TOTAL OF 10 NAUTICAL MILES WOULD BE COVERED 2699
IN A ROUNDTRIP OPERATION. EMISSION FACTORS FOR DIESEL SHIPS 2799
(0002,3-11) WERE USED IN COMPUTING AIR POLLUTANTS DUE TO 2899
TUGBOATS. 2999
** AIR EMISSIONS (TONS/YR) ** 3099

COMPONENT	COASTAL EMISSIONS	IN-BERTH EMISSIONS	TUGBOAT EMISSIONS	
				3199
PARTICULATES	2.00E-02	7.50E-03	1.00E-02	3299
SOX	3.55E-01	1.52E-01	7.50E-03	3399
CO	1.00E-04	4.00E-05	6.00E-03	3499
HC	1.00E-02	4.50E-03	4.50E-03	3599
NOX	2.30E-01	1.00E-01	7.00E-03	3699
ALDEHYDES	2.00E-03	1.00E-03	3.50E-04	3799

3899

2025 199

IT WAS ASSUMED THAT THE AIR EMISSIONS FOR SUPERTANKERS (OVER 100000 299
DWT) WERE THE SAME AS THOSE FOR SMALLER TANKERS 399

2026

FROM (0020,1/8), TANKERS LOSE APPROXIMATELY 0.11P OF THEIR CARGOES IN DISCHARGES, LEAKS AND SPILLS. THIS IS ASSUMED TO OCCUR WITHIN THE COASTAL WATERS OF THE U.S.

2027

FROM (0020,1/8), BARGES LOSE APPROXIMATELY 0.028P OF THEIR CARGOES IN DISCHARGES, LEAKS AND SPILLS.

2028

THE FOLLOWING APPROACH WAS USED IN COMPUTING THE EMISSIONS FOR DOMESTIC TRANSPORT OF CRUDE OIL BY BARGE.

1. BARGES ARE ASSUMED TO BE IN THE 10000 TON CLASS (CARRYING CAPACITY). THIS IS BASED ON THE MAXIMUM 125 FT BOTTOM WIDTH ALONG THE GULF INTRACOASTAL WATERWAY (2007,11-5)
2. ROUNDTRIP MILEAGE IS 3000 MILES. THIS IS BASED ON THE AVERAGE ROUNDTRIP DISTANCE BETWEEN PETROLEUM SHIPPING CENTERS AND CITIES ON THE MISSISSIPPI AND GULF INTRACOASTAL WATERWAYS. (2007,11-5)
3. FOR SHIPPING 178000 BBL CRUDE OIL (EQUIVALENT TO 1.0E12 BTU AND 27200 TONS), AN INTEGRATED TOWBARGE CONSISTING OF THREE 10000 TON BARGES AND TOWBOAT WOULD BE USED. A TOWBARGE OF THIS SIZE WOULD TYPICALLY HAVE AN OFF-LOADING RATE OF 2000 BPH/BARGE. IT WILL HAVE AN UPSTREAM SPEED OF 6MPH AND A DOWNSTREAM SPEED OF 12.5 MPH. (2007,11-11)
4. A LOADING RATE OF 5000 BPH IS USED FOR PETROLEUM PRODUCTS. (2007,11-11)
5. TOWBARGES ARE DIESEL POWERED
6. APPROXIMATELY THREE HOURS EACH IS ALLOWED FOR HOOKING UP AND TAKING DOWN PUMP LINES.
7. ALL OF THE ABOVE RESULT IN A TRAVELLING TIME OF 15.5 DAYS AND AN IN-BERTH TIME OF 2.7 DAYS. EMISSION FACTORS FROM (0002,3-11) FOR DIESEL MOTORSHIPS.

** AIR EMISSIONS (TONS/YR) **

COMPONENT	UNDER-WAY EMISSIONS	IN-BERTH EMISSIONS
PARTICULATES	3.00E+00	2.20E-02
SOX	2.25E+00	5.80E-02
CO	1.80E+00	6.20E-02
HC	1.35E+00	4.50E-02
NOX	2.10E+00	6.80E-02
ALDEHYDES	1.05E-01	4.00E-03

2029

TRANSPORT OF CRUDE OIL BY TRUCK BASED ON DIESEL POWERED TRACTOR-TRAILER COMBINATION WITH 8500 GAL PAYLOAD. PAYLOAD AT 62P OF GROSS WT. 150 TON-MI/GAL FUEL CONSUMPTION. ROUNDTRIP DISTANCE OF 500 MILES. EMISSION FACTORS FROM (0002,3-7)

2030

BASED ON (0021,31/32) THE AVERAGE FREIGHT TRAIN TRANSPORTS 1791 TONS OF CARGO, HAS 70 CARS AND 3 LOCOMOTIVES. TO TRANSPORT 178000 BBL/YR CRUDE OIL, APPROXIMATELY 16 TRAIN TRIPS ARE REQUIRED. EMISSIONS BASED ON AN ENERGY REQUIREMENT OF 690 BTU/TON-MI (FOOTNOTE 7013), 5.83E06 BTU/BBL (0005,38) AND A 500 MILE ROUNDTRIP. EMISSION FACTORS FROM FOOTNOTE 7020.

2031

BASED ON EMISSIONS FACTORS FOR HEAVY TRUCKS AND BUSES (0002,3-7) AND AN ENERGY REQUIREMENT OF 450 BTU/TON-MI (7012,6). PIPELINE MOVEMENT AVERAGES 300 MILES (0010,244).

2032

EMISSIONS FOR PRODUCT TRANSPORT, ON THE AVERAGE, ARE THE SAME AS THOSE FOR CRUDE OIL. THIS IS BASED ON THE AVERAGE VOLUME OF PRODUCT EQUIVALENT TO 1.0E12BTU (0005,38). FOR SPECIFIC PRODUCTS THE FOLLOWING MULTIPLIERS CAN BE APPLIED TO THE EMIS-

SIONS FOR A PARTICULAR MODE OF TRANSPORTATION.

REFINERY PRODUCT	EMISSION MULTIPLIER
GASOLINE	0.934
LPG	0.714
KEROSINE	1.009
DISTILLATE FUEL OIL	1.037
RESIDUAL FUEL OIL	1.119
COKE	1.071
ASPHALT	1.181
PETROCHEMICAL FEEDSTOCKS	0.934

TRANSPORT MODE	REFERENCE FOOTNOTE
PIPELINE	2031
TANKER	2024,2026
SUPERTANKER	2024,2025,2026
BARGE	2027,2028
TANK TRUCK	2029
TANK CAR	2030

2033

BASED ON 1971 DATA FOR PRODUCTION OF OIL AND GAS(0035,4), 595 DISABLING WORK INJURIES, 20235 MAN-DAYS LOST, 13 DEATHS. ALLOCATION TO GAS AND OIL PRODUCTION IS MADE ON THE BASIS OF 1971 DATA FOR THE PRODUCTION OF MINERAL ENERGY (0004,20), UNPROCESSED NATURAL GAS 2.487E16 BTU, CRUDE PETROLEUM 1.956E16 BTU. ON THIS BASIS THE ALLOCATION FRACTION FOR OIL IS 0.44. THE ALLOCATION TO 1.0E12 BTU/YR IS MADE ON THE BASIS OF THE 1971 OIL PRODUCTION GIVEN ABOVE. ON THIS BASIS, THE ALLOCATION FRACTION IS 5.11E-05. ALLOCATION TO ONSHORE AND OFFSHORE IS MADE ON THE BASIS OF 1963 PRODUCTION OF CRUDE OIL AT 2.75 E9 BBL INCLUDING 1.75E8 BBL FROM OFFSHORE FACILITIES (0010, 53). ON THIS BASIS THE ALLOCATION FRACTIONS ARE 0.065 OFFSHORE AND 0.935 ONSHORE.

2034

BASED ON 1971 DATA FOR TRANSPORT OF CRUDE OIL BY PIPELINE, 83 DISABLING WORK INJURIES, 2517 MAN-DAYS LOST, 1 DEATH (0035, 4). TOTAL CRUDE OIL TRANSPORTED BY PIPELINE IN 1970 IS 5.298 E09 BBL (0011,561) THE ALLOCATION TO 1.0E12 BTU/YR IS 3.36 E-05.

2035

THE OIL EMITTED TO WATERBODIES FROM OFFSHORE PRODUCTION IS THAT OIL RELEASED BY THE INCOMPLETE SEPARATION OF BRINE AND OIL AT THE WELL AND IS BASED ON A BRINE PRODUCTION OF 2.7 BBL PER BBL CRUDE OIL AND 50 PPM OIL CONTENT IN THE BRINE (2003,102). THE BRINE ITSELF IS NOT CONSIDERED A POLLUTANT TO THE RECEIVING WATERBODY.

2036

AIR EMISSIONS FROM CRUDE OIL STORAGE TANKS ARE BASED ON EMISSION FACTORS FROM(0002,4-4). IT IS ASSUMED THAT ALL TANKS ARE OF FIXED ROOF DESIGN. IT IS ALSO ASSUMED THAT CRUDE STORAGE WOULD HAVE 30 DAYS CAPACITY OR 16200 BBL. YEARLY THRUPUT IS 178000 BBL(EQUIVALENT TO 1.0E12 BTU). WATER EMISSIONS BASED ON (2009, TABLE 5).

2037

AIR EMISSIONS FOR PRODUCT STORAGE TANKS ARE BASED ON EMISSION FACTORS FROM(0002,4-4). IT IS ASSUMED THAT ALL TANKS ARE OF FIXED ROOF DESIGN. IT IS ALSO ASSUMED THAT PRODUCT TANKS WOULD HOLD 30 DAYS PRODUCTION OR 16636 BBL. YEARLY THRUPUT IS 183000 BBL,BASED ON AVERAGE HEAT CONTENT OF PETROLEUM PRODUCTS(0005,38). WATER EMISSIONS BASED ON(2009,TABLE 5)

2038

AIR EMISSIONS RESULTING FROM FILLING LOSSES FROM LOADING UNDER-GROUND STORAGE TANKS AT SERVICE STATIONS ONLY ARE CONSIDERED HERE. BASED ON(0005,38) THE BBL/YR OF GASOLINE EQUIVALENT TO 1.0E12 BTU/YR IS 190500. AIR-EMISSION FACTORS FROM(0002,4-5) ASSUMING 50P SPLASH FILL AND 50P SUBMERGED FILL.

2039

AIR EMISSIONS RESULTING FROM SPILLAGE AND FILLING LOSSES IN FILLING AUTOMOBILE GAS TANKS AT SERVICE STATIONS ONLY ARE CONSIDERED HERE. BASED ON (0005,38) THE BBL/YR OF GASOLINE EQUIVALENT TO 1.0E12 BTU/YR IS 190500. AIR EMISSION FACTORS FROM (0002,4-5).

2040

BASED ON(2012,56/57), A 100000 BPSD REFINERY WILL HAVE A LAND REQUIREMENT OF 1900 ACRES WITH 220 ACRES OCCUPIED BY PROCESS EQUIPMENT AND 390 ACRES AS A BUFFER ZONE. 178000 BBL/YR (EQUIVALENT TO 1.0E12 BTU/YR) IS EQUAL TO 540 BPSD. IMPACT GIVEN IS A RESULT OF A STRAIGHT RATIO.

2041

TOTAL CRUDE OIL SUPPLIED TO REFINERIES IN 1971 WAS 4.088E09 BBL, BASED ON(0005,14). ALLOCATION FACTOR FOR 1.0E12 BTU/YR IS 4.35E-05, USING 178000 BBL/YR EQUIVALENT TO 1.0E12 BTU/YR. FOR 1971 THERE WERE 831 DISABLING INJURIES AND 10 DEATHS IN THE REFINING INDUSTRY(0035,4). TOTAL MANDAYS LOST WERE 47170.

2042

TOTAL PRODUCTS MOVED BY PIPELINE IN 1971 WAS 2.658E09 BBL(0005,29) ALLOCATION FACTOR FOR 1.0E12 BTU/YR,EQUIVALENT TO 183000 BBL/YR BASED ON AVERAGE HEAT CONTENT OF PETROLEUM PRODUCTS (0005, 38) IS 6.9E-05. FOR 1971 THERE WERE 62 DISABLING WORK INJURIES AND ONE DEATH IN THE PRODUCTS PIPELINE INDUSTRY (0035,5). TOTAL MAN-DAYS LOST WERE 1455.

2043

BASED ON(2004,49) THE CAPITAL COST OF A 100000 BPSD ELECTROSTATIC DESALTER IS 741000 DOLLARS AND ITS OPERATING COST IS 0.595 CENTS/BBL. BASED ON(2004,32,40,44) THE CAPITAL COST OF A 1.0E5 BPSD ATMOSPHERIC AND 2-STAGE VACUUM FRACTIONATION UNIT IS 15.97E06 DOLLARS AND ITS OPERATING COST IS 24.95 CENTS/BBL. FIXED CHARGE RATE IS 10P.1972 DOLLARS.BPSD EQUIVALENT TO 1.0 E 12 BTU/YR IS 540.

2044

BASED ON(2004,94) THE CAPITAL COST OF A 40000 BPSD DISTILLATE HYDROTREATER IS 3.2E06 DOLLARS AND ITS OPERATING COST IS 24.3 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 521.

2045

BASED ON(2004,84) THE CAPITAL COST OF A 50000 BPSD CATALYTIC CRACKING UNIT IS 11.75E06 DOLLARS AND ITS OPERATING COST IS 40.8 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 534.

2046

BASED ON(2004,71) THE CAPITAL COST OF A 23000 BPSD CATALYTIC REFORMER IS 8.05E06 DOLLARS AND ITS OPERATING COST IS 68.7 CENTS PER BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 576.

2047

BASED ON(2004,65) THE CAPITAL COST OF A 10000 BPSD DELAYED COKER IS 8.0E06 DOLLARS AND ITS OPERATING COST IS 53.5 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0 E12 BTU/YR IS 482.

2048

BASED ON(2004,190) THE CAPITAL COST OF A 14000 BPSD DISTILLATE HYDROCRACKER IS 7.21E06 DOLLARS AND ITS OPERATING COST IS 125.2 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 521.

2049

BASED ON(2006,126) THE CAPITAL COST OF A 1000 BPSD ISOMERATION UNIT IS 0.585E06 DOLLARS AND ITS OPERATING COST IS 62.1 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 655.

2050

BASED ON(2004,89) THE CAPITAL COST OF A 6000 BPSD H2SO4 ALKYLATION UNIT IS 1.65E06 DOLLARS AND ITS OPERATING COST IS 125.3 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 718.

2051

BASED ON(2004,91) THE CAPITAL COST OF A 3000 BPSD PROPANE DEASPHALTING PLANT IS 1.05E06 DOLLARS AND ITS OPERATING COST IS 34.7 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 482.

2052

BASED ON(2010,176/182) T E CAPITAL COST OF A 100MMSCFD HYDROGEN PLANT IS 13.3E06 DOLLARS AND ITS OPERATING COST IS 18.25 CENTS PER MSCF H2. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. SCFD H2 RESULTING FROM 1.0E12 BTU/YR NATURAL GAS FEED IS 5.55E06.

2053

BASED ON(2004,122) THE CAPITAL COST OF A 3500 BPSD FURFURAL REFINING UNIT IS 3.0E06 DOLLARS AND ITS OPERATING COST IS 59.6 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSP EQUIVALENT TO 1.0E12 BTU/YR IS 500.

2054

BASED ON(2004,132) THE CAPITAL COST OF A 4000 BPSD SOLVENT DEWAXING UNIT IS 7.68E06 DOLLARS AND ITS OPERATING COST IS 96.6 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 500.

2055

BASED ON(2004,115) THE CAPITAL COST OF A 42000 BPSD GASOLINE TREATING UNIT IS 2.97E06 DOLLARS AND ITS OPERATING COST IS 4.25 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 606.

2056

BASED ON(3000,2-52) THE CAPITAL COST OF A 3000 BPSD SOUR GAS TREATING UNIT IS 0.403E06 DOLLARS AND ITS OPERATING COST IS 99760 DOLLARS/YR. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR (BASED ON LPG) IS 755.

2057

BASED ON(2006,153,156,164,165,167,168,169,180) THE CAPITAL COST OF A 4000 BPSD LUBE HYDROTREATER IS 0.94E06 DOLLARS. BASED ON (2004,152) THE OPERATING COST IS 29.4 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 500.

2058

BASED ON(2004,199) THE CAPITAL COST OF A 2500 BPSD AROMATICS EXTRACTION UNIT IS 12.4E06 DOLLARS AND ITS OPERATING COST IS 163.1 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 606.

2059

BASED ON(2006,206) THE CAPITAL COST OF A 500 BPSD WAX DEOILING UNIT IS 0.615E06 DOLLARS. BASED ON (2004,157) THE OPERATING COST IS 110.5 CENTS/BBL. FIXED CHARGE RATE IS 10P. 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 550.

FTN. 2060-2066

2060

LAND IMPACT FOR PIPELINE TRANSPORT OF REFINED PRODUCTS IS BASED ON 1971 TOTAL PRODUCT LINE MILEAGE OF 72406(2001,2) AND TOTAL PRODUCTS TRANSPORTED BY PIPELINE IN 1971 OF 2.658E09 BBL(0005, 29) ASSUMING AN AV PIPELINE RIGHT-OF-WAY OF 62.5 FT(2002,14) ABOUT 37.9 ACRES ARE AFFECTED.

2061

BASED ON 40.5 ONSHORE OR 2.36 OFFSHORE OIL WELLS FOR PRODUCTION OF OIL EQUIVALENT TO 1.0E12 BTU/YR(SEE FOOTNOTE 2001).IN 1970 A TOTAL OF 12547 OIL WELL WERE BROUGHT INTO PRODUCTION AT A COST OF 1.088E09 DOLLARS INCLUDING 533 OFFSHORE WELLS AT A COST OF 2.82E08 DOLLARS(0004,45). ON THIS BASIS THE AVERAGE COST/WELL IS 6.73E04 DOLLARS FOR ONSHORE AND 5.30E05 FOR OFFSHORE. IF OIL PRODUCTION FROM WELLS PRODUCING BOTH OIL AND GAS,THEN THE COST/WELL ATTRIBUTABLE TO OIL IS 5.21E04 DOLLARS ONSHORE AND 4.1E05 DOLLARS OFFSHORE, BASED ON ALLOCATION FACTORS FROM FOOTNOTE 2001. FIXED CHARGE RATE IS 10P.

2062

BASED ON 183000 BBL/YR PRODUCT(0005,38) AND FOOTNOTE 2003.

2063

BASED ON 183000 BBL/YR PRODUCT(0005,38) AND FOOTNOTE 2026.

2064

BASED ON 183000 BBL/YR PRODUCT(0005,38) AND FOOTNOTE 2027.

2065

INCLUDES ONLY HYDROCARBON EMISSIONS. NO OTHER EMISSION DATA AVAILABLE.

2066

NATIONAL AVERAGE REFINERY POLLUTANTS

WATER EMISSIONS

BASED ON(2013,VII-7), AVERAGE STANDARD RAW WASTE LOAD FOR REFINERY EFFLUENTS AFTER THE API SEPARATOR ARE

BOD 265000 LB/DAY

COD 773000 LB/DAY

ORGANICS INCLUDING

OIL 216000 LB/DAY

PHENOL 14000 LB/DAY

TOTAL SUSPENDED SOLIDS 852000 LB/DAY

OTHER DISSOLVED SOLIDS INCLUDING

SULFIDES 17000 LB/DAY

AMMONIA 38000 LB/DAY

TOTAL CHROMIUM 400 LB/DAY

THE LOADS ABOVE ARE BASED ON REFINERY THROUGHPUT OF 3.41E06 BPSD. TO OBTAIN LOADINGS FOR A REFINERY PROCESSING 1.0E12 BTU/YR(EQUIVALENT TO 178000 BBL/YR) MULTIPLY THE LOADINGS GIVEN ABOVE BY 2.61E-05. THE RESULT IS IN TONS/YR.

THERMAL POLLUTION(TDS FOUND IN SIMILAR MANNER)

TO OBTAIN THE TOTAL NATIONAL AVERAGE REFINERY THERMAL POLLUTION, THE THERMAL POLLUTION FOR EACH PROCESS IS MULTIPLIED BY THE RATIO OF BBL OF CRUDE/YR EQUIVALENT TO 1.0E12 BTU/YR DIVIDED BY BBL OF FEED/YR TO THE PROCESS EQUIVALENT TO 1.0E 12 BTU/YR AS GIVEN IN FOOTNOTES 2005 THROUGH 2023. THIS RESULT IS THEN MULTIPLIED BY THE RATIO OF THE PROCESS CAPACITY DIVIDED BY THE REFINERY CRUDE INPUT FOR THE TYPICAL REFINERY IN (2009,FIG.3). THESE RESULTS ARE SUMMED TO OBTAIN THE THERMAL POLLUTION ON THE REFINERY LEVEL.

AIR EMISSIONS

AIR POLLUTANTS RESULT FROM THE COMBUSTION OF FUELS IN THE REFINERY, FROM THE CATALYTIC CONVERSION OF CRUDE OIL TO GASOLINES, FROM STORAGE TANKS AND MANY OTHER SOURCES. FROM(0005,21) THE FOLLOWING FUELS WERE CONSUMED IN U.S. REFINERIES IN 1971,BASED ON 4.088E09 BBLS OF CRUDE PROCESSED

(1) FUEL OIL 3.81E07 BBLS
(2) NATURAL GAS 1.063E12 SCF
(3) REFINERY GAS 1.013E12 SCF
(4) PETROLEUM COKE 1.044E07 SHORT TONS
(5) LPG 6.85E06 BBLS
(6) COAL 4.05E05 SHORT TONS

EMISSIONS ARE BASED ONLY ON THE FIRST FOUR FUELS AS THEY COMPRISE 98.7P OF THE TOTAL FUELS ENERGY INPUT TO THE REFINERIES.

HYDROCARBON EMISSIONS FROM STORAGE TANKS-ASSUMING THE USE OF FIXED ROOF TANKS ONLY AND 30 DAYS STORAGE OF CRUDE AND PRODUCTS, THE TOTAL HC EMISSION ATTRIBUTABLE TO THE REFINERY IS 160.5 TONS/YR,FROM FOOTNOTES 2036 AND 2037.

HYDROCARBON EMISSIONS FROM PROCESS DRAINS- TOTAL WASTEWATER FLOW FOR A REFINERY PROCESSING 178000 BBL/YR IS 9.078E06 GAL PER YEAR(2009,2011). AIR POLLUTANT EMISSION FACTOR FROM(0002,9-4). TOTAL HC EMISSION ATTRIBUTABLE TO THE REFINERY IS 22.7 TONS/YR.

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS-BASED ON AIR POLLUTANT EMISSION FACTOR FROM(0002,9-3) AND REFINERY CAPACITY OF 178000 BBLS/YR. TOTAL HC EMISSION ATTRIBUTABLE TO THE REFINERY IS 26.7 TONS/YR

HYDROCARBON EMISSIONS FROM MISCELLANEOUS SOURCES-MISCELLANEOUS SOURCES INCLUDE PIPELINE VALVES AND FLANGES,VESSEL RELIEF VALVES, PUMP AND COMPRESSOR SEALS,AIR BLOWING,SAMPLING,ETC. AIR POLLUTANT EMISSION FACTORS FROM(0002,9-4) AND REFINERY CAPACITY OF 178000 BBLS/YR. TOTAL HC EMISSION ATTRIBUTABLE TO THE REFINERY IS 6.32 TONS/YR

HYDROCARBON EMISSIONS FROM VACUUM JETS-APPROXIMATELY 40P OF THE FEED TO THE ATMOSPHERIC/VACUUM DISTILLATION PROCESS IS SUBJECTED TO VACUUM DISTILLATION. FOR A REFINERY PROCESSING 178000 BBL/YR, THIS AMOUNTS TO 71200 BBL/YR. AIR POLLUTANT EMISSION FACTORS FROM(0002,9-4). TOTAL HC EMISSION ATTRIBUTABLE TO THE REFINERY IS 4.63 TONS/YR

AIR EMISSIONS FROM CATALYTIC CRACKER AND CATALYST REGENERATOR THE EMISSIONS FOR THE CAT CRACKING OPERATION ARE GIVEN IN FOOTNOTE 2007 FOR A FEED OF 176000 BBLS/YR (EQUIVALENT TO 1.07E12 BTU/YR). TO OBTAIN THE AIR EMISSIONS ATTRIBUTABLE TO A REFINERY PROCESSING 178000 BBLS/YR, MULTIPLY THE PROCESS EMISSIONS BY 0.505. THESE EMISSIONS ARE PARTICULATES AT 2.71 TPY,SOX AT 13.3 TPY, CO AT 611.0 TPY, HC AT 9.78 TPY, NOX AT 2.80 TPY, ALDEHYDES AND OTHERS AT 3.245 TPY.

AIR EMISSIONS FROM FUELS COMBUSTION-THE FOLLOWING QUANTITIES OF FUELS ARE REQUIRED FOR A 178000 BBL/YR REFINERY BASED ON THE 1971 DISTRIBUTION- FUEL OIL AT 1.5P SULFUR-1660 BBLS, NATURAL GAS-4.64E07 SCF, REFINERY GAS-4.41E07 SCF AND PETROLEUM COKE AT 1.8P SULFUR AND 1.4P ASH -4.55E02 SH.TONS. AIR POLLUTANT EMISSION FACTORS FROM(0002,1-3,1-7,1-9). PETROLEUM COKE ASSUMED TO BE SIMILAR TO BITUMINOUS COAL. REFINERY GAS ASSUMED TO BE SIMILAR TO NATURAL GAS EXCEPT FOR SULFUR. THE REFINERY GAS IS ASSUMED TO CONTAIN 48.8P OF THE TOTAL SULFUR IN THE CRUDE LISTED AS UNACCOUNTED FOR, RECOVERED IN AND EMITTED BY CLAUS PLANTS(2024,2025).THE UNCONTROLLED REFINERY DOES NOT CONTAIN A CLAUS PLANT. AVERAGE SULFUR CONTENT OF CRUDE FROM FOOTNOTE 2000.

FTN. 2067-2071

COMPONENT	FUEL OIL	NATURAL GAS	REFINERY GAS	PETROLEUM COKE	9199
					9299
PARTICULATES	8.01E-01	4.17E-01	3.97E-01	4.77E+00	9399
SOX	8.30E+00	1.39E-02	2.03E+02	1.56E+01	9499
CO	7.00E-03	9.36E-03	8.93E-03	2.27E-01	9599
HC	1.05E-01	9.26E-01	8.82E-01	6.84E-02	9699
NOX	2.77E+00	5.32E+00	5.07E+00	6.82E+00	9799
ALDEHYDES,ETC.	3.45E-02	2.31E-01	2.21E-01	1.14E-03	9899

EMISSIONS GIVEN ABOVE ARE IN TONS/YEAR 9999

2067 199

TRUCK TRANSPORT OF CRUDE OIL 299
BASED ON THE 1968 VOLUME OF INTERCITY HIGHWAY FREIGHT TRAFFIC 399
OF 3.963E11 TMI(0010,267) AND THE 1968 SHIPMENT OF CRUDE OIL 499
BY TRUCK OF 4.09E07 TONS(0010,272). DISTANCE FOR LADEN TRIP IS 599
ASSUMED TO BE 250 MILES, GIVING 1.02E10 TMI OF CRUDE OR 2.6P 699
OF THE TOTAL 1968 VOLUME. THE UNIT OF 1.0E12 BTU/YR IS 0.065P 799
OF CRUDE OIL SHIPMENTS. THE PRODUCT OF THESE TWO FRACTIONS AND 899
THE HIGHWAY RIGHT-OF-WAY AREA IN THE 48 STATES, 2.1E07 AC(SEE 999
FOOTNOTE 7026) GIVES 352 AC-YR/1.0E12 BTU. 1099

2068 199

TRUCK TRANSPORT OF PETROLEUM PRODUCTS 299
BASED ON THE 1968 VOLUME OF INTERCITY HIGHWAY FREIGHT TRAFFIC 399
OF 3.963E11 TMI(0010,267) AND THE 1968 SHIPMENT OF PETROLEUM 499
PRODUCTS BY TRUCK OF 4.088E08 TONS(0010,272). DISTANCE FOR 599
LADEN TRIP IS ASSUMED TO BE 250 MILES, GIVING 1.022E11 TMI OF 699
PRODUCT OR 25.8P OF THE TOTAL 1968 VOLUME. THE UNIT OF 1.0E12 799
BTU/YR IS 0.0067P OF THE PRODUCT SHIPMENTS. THE PRODUCT OF 899
THE TWO FRACTIONS AND THE HIGHWAY RIGHT-OF-WAY AREA IN THE 48 999
STATES, 2.1E07 AC(SEE FOOTNOTE 7026) GIVES 363 AC-YR/1.0E12 1099
BTU. 1199

2069 199

RAILROAD TRANSPORT OF PETROLEUM PRODUCTS 299
BASED ON THE 1968 VOLUME OF INTERCITY RAILROAD FREIGHT TRAFFIC 399
OF 7.568E11 TMI(0010,267) AND THE 1968 SHIPMENT OF PETROLEUM 499
PRODUCTS BY RAILROAD OF 2.518E07 TONS(0010,272). DISTANCE FOR 599
LADEN TRIP IS ASSUMED TO BE 250 MILES, GIVING 6.295E09 TMI OF 699
PRODUCT OR 0.832P OF THE TOTAL 1968 VOLUME. THE UNIT OF 1.0E12 799
BTU/YR IS 0.108P OF THE PRODUCT SHIPMENTS. BASED ON 365000 MI 899
OF TRACK(0011,556) AND A RIGHT-OF-WAY OF 50 FT.(2014,19-8),THE 999
RAILROAD RIGHT-OF-WAY AREA IS 2.21E06 AC. THE PRODUCT OF THE 1099
TWO FRACTIONS AND THE RIGHT-OF-WAY GIVES 19.9 AC-YR/1.0E12 BTU 1199

2070 199

RAILROAD TRANSPORT OF CRUDE OIL 299
BASED ON THE 1968 VOLUME OF INTERCITY RAILROAD FREIGHT TRAFFIC 399
OF 7.568E11 TMI AND THE 1968 SHIPMENT OF CRUDE OIL BY RAILROAD 499
OF 1.0668E06 TONS. DISTANCE FOR LADEN TRIP IS ASSUMED TO BE 599
250 MI, GIVING 2.667E08 TMI CRUDE OIL OR 0.035P OF THE TOTAL 699
1968 VOLUME. THE UNIT OF 1.0E12 BTU/YR IS 2.56P OF CRUDE OIL 799
SHIPMENTS. THE PRODUCT OF THESE TWO FRACTIONS AND THE RAILROAD 899
RIGHT-OF-WAY AREA OF 2.21E06 AC(SEE FOOTNOTE 2069) GIVES 19.8 999
AC-YR/1.0E12 BTU. 1099

2071 199

THE LAND AREA REQUIRED FOR A STORAGE TERMINAL HANDLING 2.2E09 299
BBL/YR IS 2000 AC. (2042) CRUDE OIL EQUIVALENT TO 1.0E12 BTU/ 399
YR IS 178000 BBL/YR. PRODUCT OIL EQUIVALENT TO 1.0E12 BTU/YR 499
IS 183000 BBL/YR. DOCKING FACILITIES AREA IS CONSIDERED NEGLI- 599
GIBLE IN COMPARISON TO THE TANK FARM. 699

2072

BASED ON OPERATING REVENUES OF $6.7E08 AND 5.3E09 BBLS CRUDE OIL TRANSPORTED. 178000 BBL/YR EQUIVALENT TO 1.0E12 BTU/YR

2073

BASED ON OPERATING REVENUES OF $5.8E08 AND 2.96E09 BBLS PRODUCT OILS TRANSPORTED. 183000 BBL/YR EQUIVALENT TO 1.0E12 BTU/YR

2074

BASED ON (2007,11-13) ESCALATED TO 1972 AND A LADEN TRIP OF 1500 MI(SEE FOOTNOTE 2028). CRUDE OIL TONNAGE IS 26600 AND PRODUCT TONNAGE IS 27300.

2075

BASED ON AN AVERAGE RATE OF 0.8 CENTS/GAL(2016,134/135). RATE INCLUDES FIXED AND OPERATING COST.

2076

BASED ON(0021, 31/32) THE AVERAGE FREIGHT RATE FOR 1970 IS 1.45 CENTS/TON-MI. LADEN TRIP MILEAGE IS 250(SEE FOOTNOTE 2030).

2077

BASED ON (2017,46/47), THE NEW 1972 BASE RATE FROM RAS TANURA TO U.S.EAST COAST IS $1.37/BBL. LADEN VOYAGE IS 10,000 MILES(SEE FOOTNOTE 2024).

2078

PRIMARY EFFICIENCY IS DEFINED AS 1 MINUS THE FRACTION OF THE PRIMARY FUEL INPUT ATTRIBUTABLE TO PHYSICAL LOSSES MINUS THE FRACTION OF THE PRIMARY FUEL INPUT USED IN THE PROCESS AS FUEL AND / OR STEAM. BY EQUATION, THE PRIMARY EFFICIENCY EQUALS (1-(Y/1.0E12)-(Z/1.0E12)) X 100P, WHERE Z IS THE BTU OF PHYSICAL LOSSES AND Y IS THE BTU OF INPUT FEED USED AS FUEL AND / OR STEAM. IT WAS ASSUMED IN FOOTNOTES 2005 THROUGH 2023 THAT ALL OF THE REFINERY PROCESSES WOULD USE NATURAL GAS AS THE PRIMARY FUEL THUS Y EQUALS 0 AND THE PRIMARY EFFICIENCY APPROACHES 1 EXCEPT FOR PHYSICAL LOSSES SUCH AS THOSE DUE TO EVAPORATION AND WASTEWATER CONTAMINANTS. THIS PROCEDURE RESULTS IN A HIGH ANCILLARY FUEL REQUIREMENT. IT CAN BE SHOWN THAT THE OVERALL PROCESS EFFICIENCY WILL BE THE SAME AS THAT IF Y WERE LARGE AND THE ANCILLARY DEMAND LOW. ALL EFFICIENCIES ARE ON A BTU BASIS. IT WAS FURTHER ASSUMED THAT OIL LOST TO WASTEWATER WOULD HAVE THE SAME HEAT CONTENT AS CRUDE OIL AND THAT HYDROCARBON LOSSES TO THE ATMOSPHERE WOULD HAVE A HEATING VALVE OF 200 BTU/LB.

2079

BASED ON FEED AND FUEL REQUIREMENTS FROM FOOTNOTE 2023.

2080

BASED ON DATA FROM (0040,TABLES 0-1/0-6)

2081

BASED ON (0012,71) 0.006P VOL. IS LOST IN LEAKAGE. THUS PRIMARY EFFICIENCY IS 99.994P.
FROM FOOTNOTE 2031, PIPELINE ENERGY IS 450 BTU/TON-MI, AVERAGE PIPELINE MOVEMENT IS 300 MILES. TONS/YR OF CRUDE AND PRODUCT ARE 26600 AND 27300(FROM FOOTNOTE 2074).

2082

BASED ON (0020,1/8) TANKERS LOSE APPROXIMATELY 0.11P OF THEIR CARGOES IN DISCHARGES,LEAKS AND SPILLS. THUS PE IS 99.89P FROM(7012,13)TANKER ENERGY IS 930 TMI/GAL, AVERAGE LADEN TRIP IS 10,000 MI

2083

BASED ON (0020,1/8) BARGES LOSE 0.028P OF THEIR CARGOES IN LEAKS AND SPILLS. THUS PE. IS 99.972P FROM(7012,13) BARGE ENERGY IS 220 TMI/GAL, AVERAGE LADEN TRIP IS 1500 MI.

FTN. 2084-2093

2084

BASED ON CAPITAL COST OF THE INDIVIDUAL PROCESSES AND THEIR ALLOCATION FACTORS. ALSO INCLUDES 43P ADDITIONAL COST FOR OFFSITE FACILITIES(2004,121). FIXED CHARGE RATE IS 10P . 1972 DOLLARS. BPSD EQUIVALENT TO 1.0E12 BTU/YR IS 540. TOTAL CAPITAL COST FOR A 100000 BPSD REFINERY IS 1.423E08 DOLLARS OPERATING COST FOUND IN SIMILAR MANNER.

2085

BASED ON GASOLINE STORAGE IN UNDERGROUND TANKS. BBL/YR GASOLINE EQUIVALENT TO 1.0E12 BTU/YR IS 190500. BASED ON FOOTNOTE 2071, 2000 ACRES ARE REQUIRED FOR A TANK FARM HANDLING 2.2E09 BBL/YR.

2086

POLLUTION FROM OFFSHORE OIL DEVELOPMENT AND PRODUCTION OPERATIONS CAN RESULT FROM BLOWOUTS DURING DRILLING, FROM RUPTURE OF THE WELL CASING DUE TO STORM OR SHIP COLLISION, FROM SPILLAGE OF OIL IN STORAGE AT THE SURFACE AND FROM PIPELINE LEAKS. THE PRINCIPAL DIFFERENCE BETWEEN OFFSHORE AND LAND OPERATIONS IS THE POSSIBILITY OF CATASTROPHIC FAILURE OF THE OFFSHORE WELL DUE TO DAMAGE OR DESTRUCTION BY SHIPPING OR STORMS. THE POTENTIAL FOR A MAJOR CATASTROPHE IS GREATER THAN ON LAND BECAUSE OF THE GROUPING OF WELLS ON PLATFORMS FOR MANY REASONS AND THE GREATER LOGISTICS PROBLEMS IN CONTROLLING A FIRE OR WELL OUT OF CONTROL (2003,CHAPTER 4).

2087

THE MAJOR CAUSE OF ALL PIPELINE ACCIDENTS IN 1970 WAS EXTERNAL CORROSION AT 43P, EARTH-MOVING EQUIPMENT ACCOUNTED FOR 20P, PERSONNEL ERRORS 4P. NATURAL CATASTROPHES SUCH AS LAND SLIDES, EARTHQUAKES AND FLOODS WERE OF MINOR MAGNITUDE IN THEIR EFFECTS ON PIPELINES. DRAGGING OF ANCHOR LINES CAN RUPTURE AN OFFSHORE PIPELINE (2003,CHAPTER 6).

2088

LARGE SCALE DISASTER CAN RESULT FROM COLLISIONS WITH OTHER VESSELS OR STRUCTURES, GROUNDINGS AND RAMMINGS WITH FIRES AND/OR EXPLOSIONS CAUSING DAMAGE TO VESSEL(S) AND/OR CREW(S).

2089

COLLISION OF TANK TRUCK OR TRAIN WITH OTHER MOVING OR STATIONARY OBJECT, RESULTING IN FIRE AND/OR EXPLOSION, AFFECTING PERSONS AND PROPERTY IN THE VICINITY.

2090

FIRE AND/OR EXPLOSION DUE TO SPARKS OR OPEN FLAMES. POSSIBLE DAMAGE TO SERVICE STATION FACILITIES, SURROUNDING PROPERTIES, PEOPLE.

2091

FIRE AND/OR EXPLOSIONS CAUSED BY GAS LEAKS, OIL LEAKS, ACTS OF GOD, OR HUMAN ERROR. POSSIBLE DAMAGE TO REFINERY, PERSONNEL, ADJACENT PROPERTIES.

2092

FIRE AND/OR EXPLOSION CAUSED BY SPARKS AND IMPROPER VENTING. MOST REFINERY FIRES AND EXPLOSIONS ARE IN THE TANK FARM.

2093

BASED ON(0005,21) THE PRIMARY FUELS (THOSE THAT ARE DERIVED FROM THE CRUDE OIL FEED) CONSUMED IN REFINERIES PROCESSING 4.088E09 BBLS OF CRUDE ARE FUEL OIL 3.81E07 BBLS EQUIVALENT TO 2.39E14 BTU,REFINERY GAS 1.013E12 SCF EQUIVALENT TO 1.00E15 BTU,PETROLEUM COKE 1.044E07 SHORT TONS EQUIVALENT TO 3.146E14 BTU. TOTAL PRIMARY FUELS USAGE IS 1.557E15 BTU. TO OBTAIN THE PRIMARY FUELS USAGE IN A REFINERY PROCESSING 178000 BBL/YR(EQUIV-

ALENT TO 1.0E12 BTU/YR) MULTIPLY BY 178000 DIVIDED BY 4.088E09 999
PRIMARY FUELS USAGE IN NATIONAL AVERAGE REFINERY IS 6.78E10. 1099
PRIMARY EFFICIENCY IS DEFINED AS THE FRACTION OF THE PRIMARY 1199
FUEL FORM ENTERING AN INDIVIDUAL PROCESS THAT IS ULTIMATELY 1299
DELIVERED BY THAT PROCESS. EXPRESSING THE PRIMARY FUEL AS 1399
A FRACTION OF THE FUEL INPUT(1.0E12 BTU/YR) WE GET 6.78E10 1499
DIVIDED BY 1.0E12 OR 6.78E-02. THUS PRIMARY EFFICIENCY IS 1 1599
MINUS 6.78E-02 OR 9.322E-01. 1699

2094 199

BASED ON(0005,21) THE ANCILLARY FUELS CONSUMED IN REFINERIES 299
PROCESSING 4.088E09 BBLS CRUDE ARE LPG 6.85E06 BBLS EQUIVALENT 399
TO 2.75E13 BTU, NATURAL GAS 1.063E12 SCF EQUIVALENT TO 1.096 499
E15 BTU,COAL 4.05E05 SHORT TONS EQUIVALENT TO 1.008E13 BTU, 599
PURCHASED ELECTRICITY 2.07E10 KWH EQUIVALENT TO 2.12E14 BTU 699
(CONVERTED AT 10235 BTU/KWH), PURCHASED STEAM 2.39E10 LBS 799
EQUIVALENT TO 2.87E13 BTU. TOTAL ANCILLARY ENERGY IS THEREFORE 899
1.374E15 BTU. TO OBTAIN THE ANCILLARY DEMAND FOR THE NATIONAL 999
AVERAGE REFINERY PROCESSING 178000 BBL/YR(EQUIVALENT TO 1.0E 1099
12 BTU/YR) MULTIPLY BY 178000 DIVIDED BY 4.088E09. 1199

2095 199

FROM (2027,13) THE API SEPARATOR PRODUCES 200 MG/L OF SUSPENDED 299
SOLIDS. THUS A 100,000 BPSD REFINERY (WHICH,FROM FOOTNOTE 399
2066, PRODUCES 5.1 MGD OF WASTEWATER) PRODUCES 4.25 TONS/DAY 499
OF SLUDGE. FOR A REFINERY PROCESSING 1.0E12 BTU/YR (EQUIVALENT 599
TO 178000 BBL/YR), THE SLUDGE AMOUNTS TO 7.57 TONS/YR. NO 699
ADDITIONAL INFORMATION IS AVAILABLE ON SOLID WASTES GENERATED 799
IN REFINERIES. 899

2096 199

COST FOR TRANSPORTING OIL VIA SUPERTANKER IS ESTIMATED AT 0.83 299
DOLLARS/BBL(2028,A16). 399

2097 199

FROM FOOTNOTE 2036, THE CRUDE STORAGE AMOUNTS TO 16200 BBLS CAPA- 299
CITY. FROM(2040,138) THE COST OF A 16200 BBL CARBON STEEL VER- 399
TICAL STORAGE TANK WITH A CONICAL ROOF IS 1.045E05 DOLLARS 499
(1972). FIXED CHARGE RATE IS 10P. OPERATING COST IS ESTIMATED 599
AT 7P OF THE CAPITAL COST/YR(2041,162/168). 699

2098 199

FROM FOOTNOTE 2037, THE PRODUCT STORAGE AMOUNTS TO 16636 BBLS 299
CAPACITY. FROM(2040,138) THE COST OF A 16636 BBL CARBON STEEL 399
VERTICAL STORAGE TANK WITH A CONICAL ROOF IS 1.055E05 DOLLARS 499
(1972). FIXED CHARGE RATE IS 10P. OPERATING COST IS ESTIMATED 599
AT 7P OF THE CAPITAL COST/YR(2041,162/168). 699

2099 199

FROM (0010,584) THE TOTAL INSURABLE VALUE OF 65045 GASOLINE SER- 299
VICE STATIONS WAS 1.724E09 DOLLARS IN 1969. THIS AMOUNT IS FOR 399
STRUCTURES, EQUIPMENT AND CONTENTS OTHER THAN OIL STOCKS. 499
ASSUMING THAT THE INSURED VALUE IS 75P OF THE ACTUAL CASH 599
VALUE, THEN THE AVERAGE ACTUAL CASH VALUE PER STATION IS 35400 699
DOLLARS. FROM(0010,322) AVERAGE GALLONS OF GASOLINE SOLD PER 799
PASSANGER CAR WAS 687.9. FROM(0010,305) THERE IS AN AVERAGE OF 899
372 AUTOMOBILES PER SERVICE STATION. THUS,THE AVERAGE SERVICE 999
STATION DISPENSES 2.56E05 GALLONS OF GASOLINE,EQUIVALENT TO 1099
3.198E10 BTU(0005,38). THEREFORE, IN ORDER TO DISPENSE THE 1199
EQUIVALENT OF 1.0E12 BTU/YR GASOLINE, APPROXIMATELY 31.27 1299
SERVICE STATIONS ARE REQUIRED AT A TOTAL CAPITAL INVESTMENT OF 1399
1.10E06 DOLLARS. FIXED CHARGE RATE IS 10P. NO INFORMATION 1499
AVAILABLE ON OPERATING COSTS. 1599

		CONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		FUEL	REGION	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)														AIR POL
		OIL	NATIONAL															
ROW	SYMBOL	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS PO_4	DISSOLVED SOLIDS NO_3	DISSOLVED SOLIDS OTHER	DISSOLVED SOLIDS TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12}BTU	PARTICULATES	NO_x	SO_x
1	[illegible]	EXTRACTION																
2	[illegible]	OFFSHORE PRODUCTION		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	OFFSHORE PRODUCTION		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	TRANS	CRUDE OIL TRANSPORT																
5	[illegible]	PIPELINE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	TANKERS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	SUPERTANKERS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	BARGES		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	TANK TRUCKS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	TANK CARS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	PROCESSING																
12	[illegible]	NATIONAL AVERAGE REFINERY		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	CRUDE OIL STORAGE TANKS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	ELECTROSTATIC DESALTING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	ATMOS. & VAC. DISTILLATION		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	CATALYTIC CRACKING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	CATALYTIC REFORMING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	DISTILLATE HYDROTREATING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	DELAYED COKING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	DISTILLATE HYDROCRACKING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	ISOMERIZATION		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	ALKYLATION		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	AROMATICS EXTRACTION		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	FURFURAL REFINING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	SOLVENT DEWAXING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	SOUR GAS TREATING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	GASOLINE TREATING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	LUBE OIL HYDROTREATING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	GREASE MANUFACTURE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	WAX DEWAXING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	PROPANE DEASPHALTING		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	HYDROGEN MANUFACTURE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
33	[illegible]	REFINERY PRODUCT STORAGE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
34	[illegible]	PRODUCT DISTRIBUTION																
35	[illegible]	PIPELINE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	[illegible]	TANKERS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
37	[illegible]	SUPERTANKERS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38	[illegible]	BARGES		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
39	[illegible]	TANK TRUCKS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
40	[illegible]	TANK CARS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
41	[illegible]	PRODUCT TERMINALS																
42	[illegible]	STORAGE TANKS		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
43	[illegible]	MARKETING																
44	[illegible]	AUTO GASOLINE TANK F		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
45																		
46																		
47																		
48																		
49																		
50																		

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						COST (DOLLARS/10^{12} BTU)			
PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/10^{12}BTU	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12}BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12}BTU	FIXED COST	OPERATING COST	TOTAL COST	ROW
																		1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.03-00 2 2001	6.20-05 4 2032	1.15-05 4 2031	1.28-01 4 2032	2000	3.00-01 3 2000	0000	1.15-04 2 2001	0000	0000	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	5.70-04 4 2032	2.01-04 4 2031	0.00-01 4 2032	2000	3.00-01 3 2000	0000	1.15-04 2 2001	0000	0000	3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]												11
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	6.30-01 3 2002	3.30-05 4 2034	2.70-03 4 2034	0.40-02 4 2034	2007	1.00+00 2 2001	3.50+00 2 2001	0000	0000	2.25+04 2 2002	9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.01-01 3 2071	0000	0000	0000	2000	1.00+00 2 2126	1.07+10 2 2002	0000	0000	1.35+05 3 2126	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	0000	0000	0000	2000	1.00+00 2 2126	1.07+10 2 2002	0000	0000	1.00+01 3 2126	7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible] 3 2071	0000	0000	0000	2000	1.00+00 2 2001	3.52+10 2 2001	0000	0000	2.25+01 3 2014	8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	3.42+02 3 2067	0000	0000	0000	2000	0000	1.18+10 2 2020	0000	0000	5.00+06 2 2071	9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.00+01 3 2070	0000	0000	0000	2000	0000	1.43+10 2 2030	0000	0000	6.14+06 2 2070	10
																		11
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.37+01 4 2101	1.00+01 4 2.05	6.35-04 2 2041	3.02-02 2 2041	2.05-00 2 2041	2001	0.30-01 3 2001	5.05+10 2 2125	6.50+00 3 2102	7.35-05 3 2102	1.25-05 3 2102	12
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.61-01 3 2071	0000	0000	0000	2002	1.00+00 2 2125	0.00+00 2 0000	1.15+04 3 2125	0.0-100 3 2125	1.85+04 3 2125	13
2005		2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.00+07 2 2001	4.00+02 3 2043	1.50+03 3 2043	4.00+03 3	14
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.21+10 2 2000	8.61+03 3 2043	4.00+04 3 2043	5.31+04 3	15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.17+00 3 2107	0000	0000	0000	0000	2001	1.00+00 2 2070	3.01+10 2 2107	1.00+04 3 2107	7.50+04 3 2107	8.15+04 3	16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.35+10 2 2000	2.02+04 3 2046	1.11+05 3 2046	1.13+05 3	17
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.50+10 2 2000	6.17+03 3 2044	4.10+04 3 2044	4.50+04 3	18
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0.17+10 2 2010	3.00+03 3 2047	3.31+04 3 2047	1.20+05 3	19
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.50+10 2 2011	2.60+04 3 2040	2.15+05 3 2040	2.42+05 3	20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	2.33+10 2 2013	3.84+03 3 2000	1.30+05 3 2000	1.71+05 3	21
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0.00+10 2 2019	1.07+04 3 2000	2.97+05 3 2000	3.17+05 3	22
0000		0000	0000	2.66+00 3 2114	0000	0000	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	1.01+05 3 2050	4.00+05 3 2050	7.31+05 3	23
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	3.70+10 2 2015	4.29+04 3 2053	6.94+04 3 2053	1.61+05 3	24
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.63+10 2 2015	6.00+04 3 2054	1.10+05 3 2054	2.50+05 3	25
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.07+00 2 2015	1.02+04 3 2050	2.51+05 3 2050	3.53+05 3	26
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	4.12+03 3 2055	8.20+05 3 2055	1.25+06 3	27
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2016	4.12+10 2 2020	1.10+04 3 2057	1.00+06 3 2057	4.01+06 3	28
0000		0000	0000	2.50+00 3 1121	0000	0000	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	0000	0000	0000	29
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	6.41+10 2 2023	6.17+04 3 2055	6.50+04 3 2055	1.20+05 3	30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0700	0000	0000	0000	0000	2001	1.00+00 2 2070	1.00+11 2 201	1.00+04 3 2001	5.52+04 3 2001	7.31+04 3	31
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	2001	5.03-01 2 2070	0.00-00 2 2010	5.10+04 2 2002	5.14+05 3 2002	6.00+05 3	32
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.00-01 3 2071	0000	0000	0000	2002	1.00+00 2 2126	0.00+00 2 0007	1.20+04 3 2126	5.00-05 3 2126	1.65+04 3 2126	33
																		34
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	3.70-01 3 2040	0.00-00 3 2010	4.70-03 3 2002	1.00-01 3 2010	2007	1.00+00 2 2001	1.00+0 2 2001	0000	0000	3.50+04 3 2075	35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.00-01 3 2071	0000	0000	0000	2001	1.00+00 2 2127	4.07+10 2 2002	0000	0000	3.65+01 3 2127	36
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 2 2127	4.07+10 2 2002	0000	0000	3.65+05 3 2127	37
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 2 2003	2.57+10 2 2001	0000	0000	2.20+05 2 2074	38
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.63+02 3 2068	0000	0000	0000	2000	0000	1.41+10 1 0000	0000	0000	0.10+04 3 2075	39
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	1.00-01 3 2075	0000	0000	0000	2000	0000	1.41+10 2 0000	0000	0000	0.00+04 3 2075	40
																		41
0000		0000	0000	1.00+00 2 2120	0000	0000	0000	1.73-01 2 2005	0000	0000	0000	2000	1.00+00 2 2120	0.00+00 2 0007	0000	0000	2124	42
																		43
0000	0000	0000	0000	1.00+00 2 2120	0000	0000	0000	0000	0000	0000	0000	2000	1.00+00 2 2120	0.00+00 2 0007	1.17+05 2 2120	0000	0000	44
																		45
																		46
																		47
																		48
																		49
																		50

TABLE 14. ENVIRONMENTAL IMPACTS, EFFICIENCY AND COST FOR CONTROLLED NATIONAL OIL SUPPLY

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FOOTNOTES FOR TABLE 14

2100

BASED ON EFFLUENT LIMITATIONS IN (2013,II-10) FOR API REFINERY
CATEGORY D AND CRUDE THROUGHPUT EQUIVALENT TO 1.0E12 BTU/YR

BOD 7.8LB/1000BBL
CCD 47.6LB/1000BBL
ORGANICS
OIL 3.9LB/1000BBL
PHENOLS .039LB/1000BBL
TOTAL SUSPENDED SOLIDS 7.8LB/1000BBL
OTHER DISSOLVED SOLIDS
SULFIDE .066LB/1000BBL
AMMONIA 3.9LB/1000BBL
TOTAL CHROMIUM .098LB/1000BBL

TOTAL DISSOLVED SOLIDS ARE REDUCED BY CONTROL OF OTHER DISSOLVED SOLIDS GIVEN ABOVE.

2101

THE AIR POLLUTANTS FOR A 1.0E12 BTU/YR CONTROLLED REFINERY ARE

POLLUTANT (TON/YR)	FUEL COMBUSTION	CAT CRACKER	STORAGE	OTHER
PARTICULATES	2.13E+00	6.03E-01	-	-
NOX	1.69E+01	2.80E+00	-	-
SOX	7.46E+00	1.33E+01	-	2.00E-01
HC	1.77E+00	4.90E-01	1.28E+01	8.53E+00
CO	2.80E-02	1.38E-01	-	-
ALDEHYDES	4.60E-01	3.25E+00	-	-

FUEL COMBUSTION EMISSIONS

CONTROL- LIMIT THE S CONTENT OF THE FUELS

THE FOLLOWING QUANTITIES OF FUELS ARE REQUIRED FOR A 178000 BBL/YR REFINERY BASED ON THE 1971 FUEL DISTRIBUTION GIVEN IN (0005,21) AND THE REPLACEMENT OF 1.8P S COKE (IN THE UNCONTROLLED REFINERY) WITH .7P S RESIDUAL FUEL OIL- 3840 BBL .7P S RESID, 46.4E06 SCF NATURAL GAS, AND 44.1E06 SCF REFINERY GAS. EMISSIONS IN TABLE ABOVE ARE BASED ON THESE FUEL CONSUMPTIONS AND EMISSION FACTORS GIVEN IN (0002,1-7, 1-9) WITH THE TWO FOLLOWING MODIFICATIONS- 1) FOOTNOTE 2125 LISTS A FUEL SAVINGS OF 1.69E10 BTU/YR FROM THE HEAT RECOVERED IN THE CO WASTE HEAT BOILER. WITH THE ASSUMPTION THAT ALL THE REFINERY GAS IS STILL USED IN THE REFINERY, FUEL OIL AND NATURAL GAS USAGE IN THE REFINERY ARE REDUCED PROPORTIONATELY BY 910 BBL AND 10.9E06 SCF RESPECTIVELY. THE POLLUTANTS ASSOCIATED WITH THIS FUEL SAVINGS ARE THUS SUBTRACTED FROM THE ORIGINAL FUEL COMBUSTION EMISSIONS EXCEPT FOR THE NOX EMISSION. SINCE A CO WASTE HEAT BOILER PRODUCES NOX EMISSIONS, IT WAS ASSUMED THESE NOX EMISSIONS WOULD CANCEL THOSE NOX EMISSIONS ATTRIBUTABLE TO THE FUEL SAVINGS. 2) RESIDUAL FUEL OIL WAS LIMITED TO .7P S AS NOTED ABOVE TO COMPLY WITH STATE REGULATIONS FOR THE ACHIEVEMENT OF AMBIENT AIR QUALITY STANDARDS. REFINERY GAS IS ASSUMED TO HAVE EMISSIONS SIMILAR TO THE COMBUSTION OF NATURAL GAS EXCEPT FOR THE H2S CONTENT. (2025) INDICATES THAT THE NEW SOURCE PERFORMANCE STANDARDS FOR REFINERIES LIMIT THE H2S IN PROCESS GAS COMBUSTED TO .1 GRAIN H2S/DSCF. THUS THE SO2 EMISSION FROM THE COMBUSTION OF REFINERY GAS IN A CONTROLLED 1.0E12 BTU/YR REFINERY IS 5.94E-01 TON SO2/YR.

CAT CRACKER EMISSIONS

CONTROL-ESP FOR PARTICULATES AND CO BOILER FOR CO

THE EMISSIONS FOR THE CAT CRACKER ARE GIVEN IN FOOTNOTE 2107 FOR A FEED OF 176000 BBL/YR (1.0E12 BTU/YR). TO OBTAIN

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FTN. 2102

THE AIR EMISSIONS ATTRIBUTABLE TO A REFINERY PROCESSING 178000 BBL/YR, MULTIPLY THE PROCESS EMISSIONS BY .505.

STORAGE EMISSIONS

CONTROL-FLOATING ROOF TANKS FOR HC

WITH THE USE OF FLOATING ROOF TANKS AND ASSUMING 30 DAYS STORAGE OF CRUDE AND PRODUCTS, THE HC EMISSIONS ARE 5.48 TON HC/YR FOR CRUDE STORAGE AND 7.30 TON HC/YR PRODUCT STORAGE AS GIVEN IN FOOTNOTES 2123 AND 2124.

OTHER EMISSIONS

CONTROL-CLAUS PLANT AND TAIL-GAS UNIT FOR H2S

(2024) INDICATES 48.8P OF THE TOTAL S IN THE CRUDE ENDS UP IN THE PROCESS GAS. FOR .79P S CRUDE(FOOTNOTE 2000) AND 178000 BBL/YR REFINERY THIS AMOUNTS TO 101.4 TON S/YR. HOWEVER .3 TON S/YR (.594 TON SO2/YR) IS EMITTED WITH THE COMBUSTED REFINERY GASES SO THAT 101.1 TON S/YR IS ACTUALLY SENT TO THE CLAUS PLANT FOR RECOVERY. WE ASSUME THE USE OF A 3 STAGE REACTOR PLANT WITH 95P RECOVERY USING A TAIL GAS CLEAN-UP UNIT TO GIVE AN OVERALL 99.9P S RECOVERY. THUS .20 TON SO2/YR IS EMITTED IN THE CLAUS PLANT TAIL GASES. HC EMISSIONS FOR A CONTROLLED REFINERY COME FROM BLOWDOWN SYSTEMS(.445 TON HC/YR), PROCESS DRAINS(.865 TON HC/YR), MISCELLANEOUS LOSSES(6.32 TON HC/YR), AND COOLING TOWERS (.90 TON HC/YR) AND HAVE BEEN COMPUTED FOR A 178000 BBL/YR REFINERY (1.0E12 BTU/YR) FROM (0002,9-3/9-4). A 1.0E12 BTU/YR REFINERY REQUIRES 3.02E08 GAL/YR OF COOLING WATER(FROM FOOTNOTE 2103) AND PRODUCES 9.078E06 GAL/YR WASTE WATER(FROM FOOTNOTE 2066).

2102

THE COSTS ASSOCIATED WITH CONTROLS ON A 1.0E12 BTU/YR REFINERY ARE GIVEN HERE.

SO2 CONTROL

A 100000 BPSD REFINERY PROCESSING .79P S CRUDE (FOOTNOTE 2000) WITH 48.8P OF THE S IN THE PROCESS GAS (FOOTNOTE 2101) PRODUCES 56.9 TON S/D IN THE REFINERY GASES. HOWEVER .16 TON S/D IS EMITTED IN THE COMBUSTED PROCESS GASES SO THAT 56.7 TON OR 50.6 LONG TON S/D ARE SENT TO THE CLAUS PLANT FOR RECOVERY. (2021,75) INDICATES A CLAUS PLANT WITH 3 CONVERTORS AND TAIL-GAS-CLEANUP FACILITIES FOR 50 LT S/D REQUIRES 1.9E06$ INVESTMENT. HENCE A 540 BPSD REFINERY REQUIRES 1026 $/YR AT 10P FCR. OPERATING COSTS FOR THE CLAUS PLANT ONLY ARE FROM (2025) AND HAVE BEEN SCALED FROM 15 TO 50 LT S/D USING A .6 EXPONENT TO GIVE 95500 $/YR. THE OPERATING COST FOR THE TAIL-GAS-CLEANUP UNIT IS FROM (2022,15) FOR RECOVERY OF 99.9P OF THE S TO THE CLAUS PLANT AND IS GIVEN AS 27500 $/YR. THUS THE TOTAL OPERATING COST IS 123000 $/YR FOR A 50.6 LT S/D CLAUS PLANT (SERVICING A 100000 BPSD REFINERY) OR 665 $/YR FOR A 1.0E12 BTU/YR REFINERY. NO CREDIT IS TAKEN FOR S RECOVERED.

CONTROL OF WATER POLLUTANTS

COSTS FOR A 2 MGD BIOLOGICAL TREATMENT PLANT LISTED BELOW ARE FROM (2013,VII-5)

PROCESS	CAPITAL COST-$	OPERATING COST-$/YR
SAND OR DUAL MEDIA FILTER	1.90E05	3.40E04
2 STAGE SOUR WATER STRIPPER	8.50E04	-
CHROMATE REMOVAL SYSTEM	6.50E04	2.00E04
EQUALIZATION	1.00E05	9.00E03
DISSOLVED AIR FLOTATION	8.50E04	9.00E03
ACTIVATED SLUDGE	1.25E06	1.12E05
SECONDARY CLARIFICATION	7.00E04	1.70E04
TOTAL	1.85E06	2.01E05

THESE COSTS WERE THEN SCALED BY A .6 EXPONENT TO GET THE 3599
COSTS FOR TREATING 5.1 MGD (100000 BPSD REFINERY REQUIRES 3699
5.1 MGD FROM FOOTNOTE 2066) AND THEN MULTIPLIED BY 5.4E-03 3799
TO GET 1747 $/YR CAPITAL COST (AT 10P FCR) AND 1904 $/YR 3899
OPERATING COST FOR A 1.0E12 BTU/YR REFINERY. 3999
CONTROL OF PARTICULATES FROM CAT CRACKER 4099
FOOTNOTE 2107 GIVES THE COSTS FOR AN ESP SERVICING A CAT 4199
CRACKER WITH 1.0E12 BTU/YR INPUT. TO OBTAIN THE COSTS FOR 4299
A 1.0E12 BTU/YR REFINERY MULTIPLY BY .505 TO GET 482 $/YR 4399
FIXED COST (AT 10P FCR) AND 220 $/YR OPERATING COST. 4499
CONTROL OF CO FROM CAT CRACKER 4599
FOOTNOTE 2107 GIVES THE COSTS FOR A CO WASTE HEAT BOILER 4699
SERVICING A CAT CRACKER WITH 1.0E12 BTU/YR INPUT. TO OBTAIN4799
THE COSTS FOR A 1.0E12 BTU/YR REFINERY MULTIPLY BY .505 TO 4899
GET 1218 $/YR FIXED COST AND 1655 $/YR OPERATING COST. 4999
STEAM-FUEL CREDIT FROM CO BOILER 5099
(2026) INDICATES THAT A CO BOILER SERVICING A 70500 BPSD 5199
CAT CRACKER WILL PRODUCE 450000 LB STEAM/HR. ASSUMING A 5299
FUEL COST OF 45C/1.0E06 BTU AND STEAM AT 60C/1000 LB 5399
GIVES A 2.24E06 $/YR CREDIT. FOR 1.0E12BTU/YR INPUT TO THE 5499
CAT CRACKER THIS SAVINGS IS 17126 $/YR AND FOR A 1.0E12 BTU5599
/YR REFINERY (MULTIPLYING BY .505) THE CREDIT IS 8660 $/YR.5699
CONTROL OF HC FROM CRUDE STORAGE TANKS 5799
FOOTNOTE 2123 INDICATES A 2000 $/YR INCREMENTAL FIXED COST 5899
FOR FLOATING ROOF STORAGE AND NO INCREMENTAL OPERATING COST5999
CREDIT FOR CRUDE SAVED BY FLOATING ROOF STORAGE 6099
HC EMISSIONS FROM FIXED ROOF TANKS ARE 67.2 T/YR FROM 6199
FOOTNOTE 2036 AND 5.5 T/YR WITH FLOATING ROOF STORAGE FROM 6299
FOOTNOTE 2123. ASSUMING 7.3 C/GAL CRUDE GIVES A 1281 $/YR 6399
CREDIT FOR HC EMISSION REDUCTION. 6499
CONTROL OF HC FROM PRODUCT STORAGE TANKS 6599
FOOTNOTE 2124 INDICATES A 2000 $/YR INCREMENTAL FIXED COST 6699
FOR FLOATING ROOF STORAGE AND NO INCREMENTAL OPERATING COST6799
CREDIT FOR PRODUCTS SAVED BY FLOATING ROOF STORAGE 6899
FOOTNOTE 2037 GIVES 93.3 TON HC/YR EMITTED FROM FIXED ROOF 6999
TANKS AND FOOTNOTE 2124 LISTS 7.3 TON HC/YR FROM FLOATING 7099
ROOF TANKS. ASSUMING 12.5C/GAL OF GASOLINE AND MOST OF THE 7199
PRODUCT STORAGE AS GASOLINE GIVES A 3486 $/YR CREDIT. 7299
CONTROL OF THERMAL POLLUTION 7399
FROM FOOTNOTES 2103 AND 2125 WITH .125 MILLIONS OF TOWER 7499
UNITS AND AN ASSUMED COST/TOWER UNIT OF 4.75 $ GIVES 6.0E057599
$ CAPITAL COST FOR A MECHANICAL DRAFT WET COOLING TOWER 7699
SERVICING A 100000 BPSD REFINERY. ASSUMING POWER COSTS ARE 7799
THE PRIMARY OPERATING COSTS AT 1 C/KWH GIVES AN OPERATING 7899
COST OF 2.17E05 $/YR. FOR A 1.0E12 BTU/YR REFINERY FIXED 7999
COSTS ARE 324 $/YR(AT 10P FCR)AND OPERATING COSTS 1172 $/YR8099
SOLID WASTE DISPOSAL COSTS 8199
(2033,38) INDICATES AN ANNUAL DISPOSAL COST OF 34.4 $/TON 8299
FOR CLAY COOLING AND STORAGE,PRIMARY AND SECONDARY HANDLING8399
FILTER PRESS DEWATERING,TRANSPORTING,SOIL BIODEGRADATION. 8499
FOOTNOTE 2104 GIVES 36.1 TON SOLID WASTES GENERATED BY 8599
CONTROLS IN A 1.0E12 BTU/YR REFINERY GIVING 1242 $/YR COST.8699

POLLUTANT-CONTROL TECHNOLOGY	CAPITAL	OPERATING	TOTAL	
SO2-CLAUS PLANT AND TAIL GAS CLEANING	1026	665	1691	8899
WATER POLLUTANTS-BIOLOGICAL OXIDATION	1747	1904	3651	8999
PARTICULATES-ESP ON CAT CRACKER	482	220	702	9099
CO-CO BOILER ON CAT CRACKER	1218	1655	2873	9199
CREDIT FOR FUEL SAVED IN CO BOILER		-8660	-8660	9299
HC-FLOATING ROOF ON CRUDE STORAGE	2000	0	2000	9399
CREDIT CRUDE SAVED BY FLOATING ROOF		-1281	-1281	9499
HC-FLOATING ROOF ON PRODUCT STORAGE	2000	0	2000	9599

CREDIT PRODUCT SAVED BY FLOATING ROOF		-3486	-3486	9699
THERMAL-MECHANICAL DRAFT WET TOWER	324	1172	1496	9799
SOLIDS-DISPOSAL BY BIODEGRADATION		1242	1242	9899
TOTAL REFINERY INCREMENTAL COSTS-$/YR	8797	-6569	2228	9999

2103 199

A 1.0E12 BTU/YR REFINERY USES 3.02E08 GAL WATER/YR FOR COOLING 299
PURPOSES AND PRODUCES 7.06E10 BTU/YR THERMAL DISCHARGE (FROM 399
FOOTNOTE 2066). THE THERMAL DISCHARGE CAN BE COMPLETELY 499
ELIMINATED BY THE USE OF A MECHANICAL DRAFT WET COOLING TOWER. 599

2104 199

SOLID WASTES ARE GENERATED BY THE ESP USED TO CONTROL PARTICULATES 299
FROM THE CAT CRACKER AND BY THE WATER POLLUTION CONTROL SYSTEM 399
FOOTNOTE 2107 GIVES 4.17 TON/YR SOLID WASTE FOR 1.0E12 BTU/YR 499
INPUT TO THE CAT CRACKER. TO CONVERT THIS FOR A 1.0E12 BTU/YR 599
REFINERY,MULTIPLY BY .505 TO GET 2.11 TON/YR FROM THE CAT 699
CRACKER. (2034,75/78) INDICATES THAT A 6.0 MGD WASTEWATER 799
TREATMENT SYSTEM PRODUCES 55000 LB/D SOLID WASTES. FOR A 5.1 899
MGD SYSTEM(100000 BPSD REFINERY) THIS BECOMES 46750 LB/D TOTAL 999
TREATMENT SYSTEM WASTES. (2027,13) NOTES THAT THE API 1099
SEPARATOR CAN PRODUCE 8320 LB/D IN TREATING 5.0 MGD WASTE 1199
WATER,OR 8500 LB/D FOR 5.1 MGD. THE UNCONTROLLED REFINERY HAS 1299
AN API SEPARATOR SO THAT ONLY 38250 LB SOLID WASTE/D ARE 1399
ATTRIBUTED TO THE CONTROLLED REFINERY WATER POLLUTION CONTROL 1499
SYSTEM. FOR A 1.0E12 BTU/YR REFINERY THIS BECOMES 34.0 TON/YR 1599
FOR WATER POLLUTION CONTROL. THE SUM TOTAL INCREMENTAL SOLID 1699
WASTE GENERATED IN A CONTROLLED 1.0E12 BTU/YR REFINERY IS 1799
THUS 36.1 TON/YR. 1899

2105 199

LAND REQUIREMENTS FOR PRINCIPAL SULFUR RECOVERY PROCESS EQUIPMENT, 299
STORAGE,INCINERATOR,AND STACK FROM (2023,107) IS .0699 ACRES 399
FOR A 50.7 LT S/D CLAUS PLANT (100000 BPSD REFINERY). FOR A 499
1.0E12 BTU/YR REFINERY THIS IS 3.77E-04 ACRES. (2035,81) 599
INDICATES THAT A 250000 GPM COOLING SYSTEM EMPLOYING TWO 699
MECHANICAL DRAFT WET COOLING TOWERS REQUIRES 1.5 ACRES LAND. 799
USING .75 ACRES/125000 GPM AND NOTING THAT A 100000 BPSD 899
REFINERY REQUIRES 117500 GPM (FOOTNOTE 2066) GIVES 4.05E-03 999
ACRES FOR A 1.0E12 BTU/YR REFINERY. (2036,62) INDICATES AN 1099
EXTENDED-AERATION ACTIVATED SLUDGE PLANT TO TREAT 5 MGD 1199
REQUIRED A 2.17 ACRE SITE. ASSUMING ABOUT AN ADDITIONAL ACRE 1299
FOR THE EQUALIZATION BASIN,DISSOLVED AIR FLOTATION,AND FINAL 1399
FILTRATION UNITS GIVES A TOTAL OF 3 ACRES FOR A 5 MGD 1499
WASTEWATER TREATMENT SYSTEM(100000 BPSD REFINERY). FOR 1.0E 1599
12 BTU/YR THIS BECOMES 1.62E-02 ACRES. THUS THE TOTAL 1699
INCREMENTAL LAND REQUIREMENT FOR CONTROLS ON A 1.0E12 BTU/YR 1799
REFINERY IS 2.06E-02 ACRES. THIS IS PROVIDED FOR IN THE 1899
REFINERY FIGURE GIVEN IN FOOTNOTE 2040. 1999

2106 199

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND 299
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/ 399
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE 499
SAME AS GIVEN IN FOOTNOTE 2006. EMISSIONS BELOW ARE IN TON/YR. 599

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				699
				799
HC	2.64E-01	4.65E-02	2.68E+00	899

2107 199

WATER POLLUTANTS AND THERMAL DISCHARGE ARE THE SAME AS GIVEN IN 299
FOOTNOTE 2007. AIR POLLUTANT SOURCES INCLUDE STEAM BOILERS AND 399
PROCESS HEATERS,BLOWDOWN SYSTEMS,PIPELINE VALVES AND FLANGES, 499
VESSEL RELIEF VALVES,PUMP AND COMPRESSOR SEALS,PROCESS DRAINS, 599
AND CATALYST REGENERATION OPERATION. AIR POLLUTANT EMISSION 699
FACTORS FROM (0002,1-9,9-3/9-4) EXCEPT AS NOTED BELOW TABLE. 799

POLLUTANT (TON/YR)	CATALYST CONVERSION	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
PARTICULATES	1.20E+00	2.42E-01	6.50E-02	-
NOX	5.54E+00	2.78E+00	7.48E-01	-
SOX	2.63E+01	7.25E-03	1.95E-03	-
HC	9.68E-01	3.63E-01	9.75E-02	2.43E+00
CO	2.72E-01	4.83E-03	1.30E-03	-
NH3	4.75E+00	0.00E+00	0.00E+00	-
OTHER ORGANICS	1.67E+00	1.21E-01	3.23E-02	-

BBL FEED EQUIVALENT TO 1.0E12 BTU/YR IS 176000 (0005,38) AND FOOTNOTE 2000.

CONVERSION SO2 EMISSIONS

3.2P OF TOTAL SULFUR IN CRUDE IS ATTRIBUTED TO REFINERY CAT CRACKER REGENERATION OPERATIONS BASED ON AN EPA SULFUR BALANCE FOR REFINERIES (2024).THUS FOR .79PS CRUDE AND A 1.0E12 BTU/YR REFINERY (178000 BBL CRUDE/YR) 13.3 TON SO2/YR ARE DISCHARGED FROM CAT CRACKER OPERATIONS. THESE REFINERY CAT CRACKER CONVERSION SO2 EMISSIONS ARE OBTAINED FOR 1.0E 12 BTU INPUT TO CAT CRACKER BY MULTIPLYING BY RATIO OF BBL OF FEED EQUIVALENT TO 1.0E12 BTU TO BBL OF CRUDE EQUIVALENT TO 1.0E12 BTU AND THEN MULTIPLIED BY RATIO OF BBL OF CRUDE PROCESSED/DAY IN THE REFINERY TO BBL OF FEED/DAY TO CAT CRACKER FROM (2009,FIG.3). NO CONTROL OF THESE CONVERSION SO2 EMISSIONS IS ANTICIPATED.

CONVERSION PARTICULATE EMISSIONS

(2029) INDICATES THAT THE NEW SOURCE PERFORMANCE STANDARDS FOR FLUID CAT CRACKERS WILL LIMIT PARTICULATE DISCHARGES TO .022 GRAINS/DSCF. (2029) ALSO NOTES THAT A 50000BPSD CAT CRACKER HAS A REGENERATOR GAS FLOW RATE OF 150000DSCFM AND WOULD THUS EMIT .339 TON PARTICULATES/D OR 6.78E-06 TON/BBL FRESH FEED IN COMPLIANCE WITH THE STANDARD.

CONVERSION CO EMISSIONS

(2029) INDICATES THAT THE NEW SOURCE PERFORMANCE STANDARDS FOR FLUID CAT CRACKERS WILL LIMIT CO EMISSIONS TO NO MORE THAN .050P VOLUME OF REGENERATOR OFFGAS. USE OF A CO WASTE HEAT BOILER IS ASSUMED FOR COMPLIANCE WITH THE STANDARD. (2029) NOTES THAT CO EMISSION FROM CO BOILERS IS ABOUT 10 PPM WHICH,FOR A 50000 BPSD CAT CRACKER (150000 DSCFM),GIVES .0772 TON CO/D OR 1.54E-06 TON CO/BBL FEED.

CONVERSION HC EMISSIONS

THE CO WASTE HEAT BOILER CAN REDUCE HC EMISSIONS FROM THE REGENERATOR OFFGAS BY 95P.

OTHER SOURCE HC EMISSIONS

TOTAL REFINERY OTHER SOURCE HC EMISSIONS ARE ALLOCATED TO THE CAT CRACKING PROCESS BASED ON THE RATIO OF CAT CRACKER CAPACITY TO TOTAL REFINERY CAPACITY FROM (2009,FIG.3),THAT IS,0.16303(SEE FOOTNOTE 2007). THESE EMISSIONS REFLECT CONTROLS ON BLOWDOWN SYSTEMS,PROCESS DRAINS,AND VACUUM JETS.

SOLID WASTES FROM CONTROLS

SOLID WASTES ARE GENERATED BY THE ELECTROSTATIC PRECIPITATOR USED TO CONTROL PARTICULATE EMISSIONS. THIS SOLID WASTE IS EQUAL TO THE DIFFERENCE IN PARTICULATE EMISSIONS FROM THE UNCONTROLLED CAT CRACKER REGENERATOR (SEE FOOTNOTE 2007) AND THE CONTROLLED REGENERATOR GIVEN ABOVE.

ENERGY REQUIREMENTS FOR CONTROLS

POWER CONSUMPTION FOR ESP TAKEN FROM (2031,393) ASSUMING PERFORMANCE SIMILAR TO THAT ON A PULVERIZED FUEL FIRED BOILER AND USING 150000DSCFM AND .9 LOAD FACTOR FOR ESP SERVICING A 50000 BPSD CAT CRACKER. ELECTRICITY CONVERTED AT 10200 BTU/KWH. ENERGY REQUIRED IS 2.90E07 BTU/YR FOR

1.0E12 BTU/YR INPUT TO CAT CRACKER. 6999
(2026) INDICATES A POWER REQUIREMENT OF 7.45E06 KWH/YR AND 7099
AN AUXILIARY FUEL REQUIREMENT OF 5.27E11 BTU/YR FOR A CO 7199
WASTE HEAT BOILER SERVICING A 70500 BPSD CAT CRACKER. FOR 7299
1.0E12 BTU/YR CAT CRACKER WE HAVE 5.81E08 BTU/YR POWER 7399
REQUIREMENT(ELECTRICITY CONVERTED AT 10200 BTU/KWH)AND 7499
4.03E09 BTU/YR AUXILIARY FUEL REQUIREMENT. THUS THE TOTAL 7599
ENERGY REQUIREMENT FOR CONTROLS ON 1.0E12 BTU/YR CAT 7699
CRACKER IS 4.64E09 BTU/YR. 7799
CONTROL COSTS 7899
FROM (2029) THE CAPITAL COST OF AN ESP SERVICING A 65000 7999
BPSD CAT CRACKER IS 1.15E06$. FOR A 539 BPSD UNIT (1.0E12 8099
BTU/YR) THE COST WOULD BE 954$/YR AT 10P FIXED CHARGES. 8199
(2029) ALSO GIVES 52500$/YR FOR OPERATING COSTS OF THE ESP 8299
WHICH TRANSLATES TO 435$/YR FOR AN ESP ON A 539BPSD UNIT. 8399
(2026) LISTS THE CAPITAL COST OF A CO WASTE HEAT BOILER 8499
SERVICING A 70500 BPSD CAT CRACKER AT 3.15E06$. FOR A 539 8599
BPSD UNIT THE COST IS 2408 $/YR AT 10P FIXED CHARGE RATE. 8699
(2026) GIVES THE OPERATING AND MAINTAINENCE COSTS FOR THE 8799
CO BOILER AT 4.28E05$/YR WHICH BECOMES 3272$/YR ON A 539 8899
BPSD UNIT. THUS THE INCREMENTAL COSTS FOR CONTROL ON A 8999
1.0E12 BTU/YR CAT CRACKER ARE 3362 $/YR FIXED, 3707 $/YR 9099
OPERATING, AND 7069 $/YR TOTAL ANNUAL. 9199
NO ACCOUNT HAS BEEN TAKEN AT THE PROCESS LEVEL FOR STEAM 9299
GENERATED IN THE CO BOILER OR FOR AIR POLLUTANTS ASSOCIATED 9399
WITH COMBUSTION OF AUXILIARY FUEL IN THIS BOILER (HOWEVER SEE 9499
FOOTNOTE 2101). AIR POLLUTANTS FROM PROCESS HEATERS AND STEAM 9599
BOILERS BASED ON A NATURAL GAS FEED. 2.416E07 SCF FUEL IS USED9699
TO PROCESS 1.0E12 BTU FEED FROM (2006,131/8) AND (0005,38). 9799
SCF FUEL FOR STEAM IS 6.50E06 BASED ON(2006,137/8)1031 BTU/SCF9899
AND 85P FUEL EFFICIENCY.ELECTRIC AT 1.04 KWH/BBL(2006,131/138)9999

2108 199
HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND 299
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/ 399
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE 499
SAME AS GIVEN IN FOOTNOTE 2008. EMISSIONS BELOW ARE IN TON/YR. 599

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				699
HC	4.98E-01	-	2.46E+00	799
				899

2109 199
HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND 299
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/ 399
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE 499
SAME AS GIVEN IN FOOTNOTE 2009. EMISSIONS BELOW ARE IN TON/YR. 599

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				699
HC	1.53E-02	6.53E-03	2.26E+00	799
				899

2110 199
HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND 299
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/ 399
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE 499
SAME AS GIVEN IN FOOTNOTE 2010. EMISSIONS BELOW ARE IN TON/YR. 599

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES	
				699
HC	6.14E-01	1.67E-01	1.99E+00	799
				899

2111 199
HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND 299
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/ 399
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE 499
SAME AS GIVEN IN FOOTNOTE 2011. EMISSIONS BELOW ARE IN TON/YR. 599

	PROCESS	STEAM	OTHER	
				699

	HEATERS	BOILERS	SOURCES
HC	4.08E-01	-	2.21E+00

2112

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2012. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	1.61E-01	1.31E-01	2.68E+00

2113

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2013. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	-	1.24E+00	4.29E+00

2114

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2014. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	-	-	2.64E+00

2115

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2015. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	6.98E-01	1.15E-01	2.17E+00

2116

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2016. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	7.10E-01	1.15E-01	2.36E+00

2117

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2017. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	5.00E-01	1.01E+00	1.97E+00

2118

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2018. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	-	1.20E-02	4.03E+00

2119

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS, PROCESS DRAINS, AND VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/

9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE
SAME AS GIVEN IN FOOTNOTE 2019. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	-	-	2.47E+00

2120

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE
SAME AS GIVEN IN FOOTNOTE 2020. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	3.75E-01	1.68E-01	2.17E+00

2121

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE
SAME AS GIVEN IN FOOTNOTE 2021. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	-	-	2.03E+00

2122

HYDROCARBON EMISSIONS FROM BLOWDOWN SYSTEMS,PROCESS DRAINS,AND
VACUUM JETS CAN BE CONTROLLED TO THE LEVEL GIVEN IN (0002,9-3/
9-4). PROCESS HEATER AND STEAM BOILER HC EMISSIONS ARE THE
SAME AS GIVEN IN FOOTNOTE 2022. EMISSIONS BELOW ARE IN TON/YR.

	PROCESS HEATERS	STEAM BOILERS	OTHER SOURCES
HC	7.91E-01	1.93E-01	2.24E+00

2123

WE ASSUME THE USE OF A 50 FT DIAMETER 50 FT HIGH FLOATING ROOF
STORAGE TANK TO STORE OUR 16200 BBL (30 DAY STORAGE) CRUDE
(SEE FOOTNOTE 2036). EMISSION FACTORS FROM (0002,4-4). (2026)
AND (2030) INDICATE NO INCREMENTAL OPERATING COSTS AND A
$20000 INCREMENTAL CAPITAL COST FOR 20000 BBL FLOATING ROOF
TANK. BASING THE HEATING VALUE OF HC EMISSIONS ON THE VALUE
OF THE CRUDE STORED GIVES A 99.979P PRIMARY EFFICIENCY FOR
THE FLOATING ROOF DESIGN. FOOTNOTE 2102 GIVES A CREDIT OF 1281
$/YR FOR HC NOT EMITTED DUE TO USE OF FLOATING ROOF TANK
AND THIS HAS BEEN CREDITED TO OPERATING COSTS.

2124

WE ASSUME THE USE OF A 50 FT DIAMETER 50 FT HIGH FLOATING ROOF
STORAGE TANK TO STORE OUR 16636 BBL (30 DAY STORAGE) OF
PETROLEUM PRODUCTS (SEE FOOTNOTE 2037). EMISSION FACTORS FROM
(0002,4-4). (2026) AND (2030) INDICATE NO INCREMENTAL
OPERATING COSTS AND A $20000 INCREMENTAL CAPITAL COST FOR
20000 BBL FLOATING ROOF TANK. BASING THE HEATING VALUE OF HC
EMISSIONS ON THE VALUE OF GASOLINE GIVES A 99.97P PRIMARY
EFFICIENCY FOR THE FLOATING ROOF DESIGN. FOOTNOTE 2102 GIVES A
CREDIT OF 3486 $/YR WITH THE USE OF FLOATING ROOF TANK
AND THIS HAS BEEN CREDITED TO OPERATING COSTS.

2125

ENERGY REQUIREMENTS FOR CONTROLS ON A 1.0E12 BTU/YR REFINERY ARE
PRESENTED HERE.

SO2 CONTROL

ENERGY REQUIREMENTS FOR THE CLAUS PLANT AND TAIL-GAS
CLEANUP UNIT ARE ASSUMED TO BE 15P OF THE OPERATING COSTS.
ASSUMING A FUEL COST OF 45C/1.0E06 BTU GIVES A FUEL
REQUIREMENT OF 2.22E08 BTU/YR.

PARTICULATE CONTROL ON CAT CRACKER

FOOTNOTE 2107 GIVES THE ENERGY REQUIREMENT FOR 1.0E12 BTU/
YR INPUT TO THE CAT CRACKER. FOR A 1.0E12 BTU/YR REFINERY
MULTIPLY THIS BY .505 TO GET 1.47E07 BTU/YR.

CC CONTROL ON CAT CRACKER
FOOTNOTE 2107 GIVES A POWER REQUIREMENT OF 5.81E08 BTU/YR AND AN AUXILLARY FUEL REQUIREMENT OF 4.03E09 BTU/YR FOR 1.01E12 BTU/YR INPUT TO THE CAT CRACKER. FOR A 1.0E12 BTU/YR REFINERY MULTIPLY THESE NUMBERS BY .505.

STEAM-FUEL CREDIT FOR CO BOILER
FOOTNOTE 2102 INDICATES A FUEL SAVINGS OF 8660 $/YR FOR A CC BOILER IN A 1.0E12 BTU/YR REFINERY. BASED ON 45C/1.0E06 BTU THIS REPRESENTS A FUEL SAVINGS OF 1.92E10 BTU/YR.

THERMAL POLLUTION CONTROL
ENERGY REQUIREMENTS FOR A .125E06 GPM MECHANICAL DRAFT WET COOLING TOWER ARE FROM (2032). ASSUMING A 70 DEGREE F WET BULB AND A 15 DEGREE F APPROACH AND WITH A 28 DEGREE F TEMPERATURE RISE (FROM FOOTNOTE 2103), (2032,N-10/N-12) GIVES A FAN POWER REQUIREMENT OF 1.05 MW AND A PUMPING POWER REQUIREMENT OF 1.7 MW FOR A TOTAL POWER REQUIREMENT OF 2.75 MW. THIS HAS BEEN CONVERTED TO BTU/YR BASED ON A .9 LOAD FACTOR AND 10200 BTU/KWH, AND SIZED FOR A 540 BPSD (1.0E12 BTU/YR) REFINERY TO GIVE AN ENERGY REQUIREMENT OF 1.19E09 BTU/YR.

WATER POLLUTION CONTROL
POWER REQUIREMENTS FOR AN EXTENDED-AERATION ACTIVATED SLUDGE PLANT TREATING 5.0 MGD WASTEWATER ARE 4.44E06 KWH/YR FROM (2036,65). POWER REQUIREMENTS FOR A DISSOLVED AIR FLOTATION UNIT TREATING 1.44 MGD WASTEWATER ARE 1.96E05 KWH/YR FROM (2037,53) OR 6.95E05 KWH/YR FOR A 5.1 MGD SYSTEM. FOOTNOTE 2102 GIVES AN OPERATING COST OF 80000 $/YR FOR THE WASTEWATER TREATMENT OPERATIONS EXCLUSIVE OF THE ACTIVATED SLUDGE AND DISSOLVED AIR FLOTATION UNITS. SCALING THIS TO 5.1 MGD WITH A .6 EXPONENT AND ASSUMING 15P OF THIS OPERATING EXPENSE IS FOR POWER COST AT 1C/KWH GIVES AN ENERGY REQUIREMENT OF 2.1E06 KWH/YR. THE TOTAL KWH REQUIREMENT FOR A 5.1 MGD WASTEWATER TREATMENT SYSTEM IS THUS 7.24E06 KWH/YR (FOR A 100000 BPSD REFINERY). MULTIPLYING THIS BY 5.40E-03 AND CONVERTING BY 10200 BTU/KWH GIVES AN ENERGY REQUIREMENT OF 3.985E08 BTU/YR FOR A 1.0E12 BTU/YR REFINERY.

TOTAL ENERGY REQUIREMENTS FOR A 1.0E12 BTU/YR REFINERY
THERE IS A 169.4E08 BTU/YR FUEL SAVINGS FOR THE REFINERY BASED ON 192.0E08 FUEL CREDIT FROM THE CO WASTE HEAT BOILER AND 22.62E08 FUEL REQUIRED FOR SO2 CONTROL AND AUXILIARY FUEL IN THE CO BOILER. THIS FUEL SAVED WAS ALLOCATED AS 57.1E08 BTU/YR FUEL OIL AND 112.3E08 BTU/YR NATURAL GAS AS NOTED IN FOOTNOTE 2101. THUS THE PRIMARY ENERGY REQUIRED IN A 1.0E12 BTU/YR REFINERY IS 6.773E10 BTU/YR (FOOTNOTE 2093) LESS .571E10 BTU/YR FOR A NEW PRIMARY EFFICIENCY OF 93.8P. THE ANCILLARY ENERGY REQUIREMENTS BECOME 5.98E10 BTU/YR (FOOTNOTE 2094) LESS 1.12E10 BTU/YR (NATURAL GAS SAVED) PLUS .19E10 BTU/YR OF ELECTRICITY REQUIRED (THE SUM OF ELECTRICITY REQUIRED FOR THE ESP, CO BOILER, THERMAL CONTROL, AND WATER POLLUTION CONTROL) FOR AN ANCILLARY ENERGY REQUIREMENT OF 5.05E10 BTU/YR.

2126

WE ASSUME THE USE OF DOUBLE BOTTOM CONSTRUCTION ON TANKERS AND SUPERTANKERS WHICH 1) PROVIDES CLEAN BALLAST STORAGE AND 2) REPRESENTS A FACTOR OF SAFETY IN THE EVENT OF GROUNDING. (0020,4) NOTES THAT 967000 METRIC TONS OF OIL/YR ARE DISCHARGED TO THE OCEAN WITH THE TANKER BALLAST AND WOULD BE COMPLETELY ELIMINATED WITH THE PROVISION FOR CLEAN BALLAST STORAGE. IN ADDITION 250000 METRIC TONS OF OIL/YR ARE LOST TO THE OCEAN THROUGH VESSEL CASUALTIES-26P OF WHICH IS ATTRIBUTED

TO GROUNDINGS. (0020,26) NOTES THAT 70P OF THE POLLUTION 1099
RESULTING FROM GROUNDINGS COULD BE ELIMINATED BY DOUBLE BOTTOM 1199
CONSTRUCTION. THE TOTAL EFFECT OF DOUBLE BOTTOM CONSTRUCTION 1299
THEN WOULD BE TO ELIMINATE 1012500 OF THE 1387000 METRIC TONS 1399
OF OIL/YR DISCHARGED TO THE OCEAN FROM TANKER OPERATIONS. 1499
374500 METRIC TONS OF OIL/YR WOULD STILL BE DISCHARGED FROM 1599
BILGE PUMPS,LEAKS,VESSEL CASUALTIES,AND TERMINAL OPERATIONS. 1699
THIS FIGURE IS FOR 1300E06 METRIC TONS OIL/YR TRANSPORTED SO 1799
THAT OIL DISCHARGED IS BASED ON .0288P OF THE TONNAGE SHIPPED. 1899
FROM THIS THE PRIMARY EFFICIENCY IS SEEN TO BE 99.9712P. 1999
THE INCREMENTAL CAPITAL COST FOR DOUBLE BOTTOM CONSTRUCTION 2099
ON A 40000 DWT TANKER IS 1.765E06 $ AND ON A 200000 DWT TANKER 2199
4.75E06 $ FROM (0020,26). A 40000 DWT TANKER CAN CARRY 352000 2299
BBL CRUDE (2007,10-7) SO THAT 178/352 TIMES 1.765E06 $ IS 2399
ATTRIBUTED TO THE TANKER TRANSPORT OF 1.0E12 BTU/YR. A 200000 2499
DWT TANKER CAN CARRY 1.65E06 BBL CRUDE (2007,10-7) SO THAT 2599
1.78E05/1.65E06 TIMES 4.75E06 $ IS ATTRIBUTED TO SUPERTANKER 2699
TRANSPORT OF 1.0E12 BTU/YR. NO INFORMATION AVAILABLE ON 2799
INCREMENTAL OPERATING COSTS. THE CREDIT FOR OIL NOT DISCHARGED 2899
BASED ON 7.3 C/GAL CRUDE AMOUNTS TO ONLY 465 $/YR. 2999

2127 199

BASED ON FOOTNOTE 2126 .0288P OF THE OIL TRANSPORTED IS LOST 299
THROUGH LEAKS,SPILLS,ETC. FOR 183000 BBL/YR OF PETROLEUM 399
PRODUCTS (1.0E12 BTU/YR) THIS AMOUNTS TO 8.07 TON OIL/YR. THE 499
PRIMARY EFFICIENCY IS 99.9712P BASED ON THE ABOVE. 599
THE INCREMENTAL CAPITAL COST FOR A DOUBLE BOTTOM CONSTRUCTION 699
FOR A 40000 DWT TANKER GIVEN IN FOOTNOTE 2126 SHOULD BE 799
MULTIPLIED BY 183/352 AND ANNUALIZED AT 10P TO GET THE 899
INCREMENTAL COST FOR TANKER TRANSPORT OF 1.0E12 BTU/YR OF 999
PETROLEUM PRODUCTS. SIMILARLY THE INCREMENTAL CAPITAL COST FOR 1099
A 200000 DWT SUPERTANKER GIVEN IN FOOTNOTE 2126 SHOULD BE 1199
MULTIPLIED BY 1.83E05/1.65E06 AND ANNUALIZED AT 10P TO GET THE 1299
INCREMENTAL COST FOR SUPERTANKER TRANSPORT OF 1.0E12 BTU/YR OF 1399
PETROLEUM PRODUCTS. THE CREDIT FOR PRODUCT NOT DISCHARGED 1499
BASED ON 9.5 C/GAL(RESID) AMOUNTS TO ONLY 545 $/YR. 1599

2128 199

1.0E12 BTU/YR OF GASOLINE IS EQUIVALENT TO 8E06 GAL GASOLINE/YR. 299
(0002,4-5) INDICATES AN UNCONTROLLED EMISSION RATE OF 9.5 LB 399
HC/1000 GAL AND (2038,11) INDICATES A 95P REDUCTION IN 499
EMISSIONS WITH THE USE OF A COMPRESSION-LIQUEFACTION VAPOR 599
RECOVERY SYSTEM. THIS REDUCES THE EMISSIONS TO 1.89 TON HC/YR. 699
BASING THE HC EMISSION HEATING VALUE ON THAT OF GASOLINE GIVES 799
A 99.99P PRIMARY EFFICIENCY FOR THIS SYSTEM. THE COST FOR THIS 899
SYSTEM IS GIVEN IN FOOTNOTE 2129 AND INCLUDES THE COST FOR 999
CONTROLING HC EMISSIONS FROM BOTH SERVICE STATION TANKS AND 1099
THE FILLING OF AUTOMOBILE GAS TANKS. 1199

2129 199

(0002,4-5) INDICATES AN UNCONTROLLED HC EMISSION RATE OF 12.0 LB 299
HC/1000 GAL FOR FILLING AUTO TANKS. (2038,4) NOTES THAT .7 LB 399
HC/1000 GAL IS DUE TO SPILLAGE AT THE VEHICLE. ASSUMING THAT 499
THE SPILLAGE IS NOT CONTROLLED AND THAT A 95P EFFICIENT 599
COMPRESSION-LIQUEFACTION VAPOR RECOVERY SYSTEM IS IN USE, 699
1.265 LB HC/1000 GAL WOULD BE EMITTED IN THE CONTROLLED 799
FILLING OF AUTOMOBILE GAS TANKS. BASED ON 190500 BBL GASOLINE 899
/YR (EQUIVALENT TO 1.0E12 BTU/YR FROM (0005,38)) THIS RESULTS 999
IN 5.06 TON HC/YR EMITTED. BASED ON THIS EMISSION AND A 1099
HEATING VALUE FOR THIS EMISSION SIMILAR TO THAT FOR GASOLINE, 1199
THE PRIMARY EFFICIENCY FOR THIS CONTROLLED PROCESS IS 99.97P. 1299
(2039) INDICATES THAT FOR A LARGE SERVICE STATION PUMPING 1399
960000 GAL GASOLINE/YR, THE COST OF A COMPRESSION- 1499
LIQUEFACTION VAPOR RECOVERY SYSTEM IS $8000 CAPITAL COST (FOR 1599

EQUIPMENT AND INSTALLATION COSTS) AND 800 $/YR IN OPERATING 1699
AND MAINTENANCE COSTS. FOR 1.0E12 BTU/YR (8E06 GAL/YR) THESE 1799
COSTS ARE 6.66E03 $/YR CAPITAL (AT 10P FCR) AND 6.66E03 $/YR 1899
OPERATING FOR A TOTAL ANNUAL COST OF 1.33E04 $/YR. HOWEVER 1999
BASED ON THE DIFFERENCE IN HC EMISSIONS FOR THE UNCONTROLLED 2099
AND CONTROLLED CASES FOR THE FILLING OF BOTH SERVICE STATION 2199
AND AUTOMOBILE TANKS, 79.05 TON HC/YR ARE NOT EMITTED WITH THE 2299
USE OF THE CONTROL SYSTEM. CONSIDERING THIS SAVINGS TO BE 2399
EQUIVALENT TO GASOLINE AND VALUED AT 12.5 C/GAL YIELDS A 2499
CREDIT OF 3204 $/YR. THUS THE TOTAL INCREMENTAL ANNUAL COST 2599
FOR THIS CONTROL SYSTEM IS 1.01E04 $/YR. 2699

		UNCONTROLLED	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		FUEL: OIL; REGION: DOMESTIC OFFSHORE	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL 12)													
ROW	MNEMONIC	ACTIVITY PROCESS	ACIDS	BASES	DISSOLVED SOLIDS: PO_4	DISSOLVED SOLIDS: NO_3	DISSOLVED SOLIDS: OTHER	DISSOLVED SOLIDS: TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12}BTU)	PARTICULATES	NO_x
1	EXTRC	EXTRACTION														
2	ONSHR	ONSHORE PRODUCTION	0000	0000	0000	0000	0000	0000	0000	1.55-01 3 2004	1.55-01 3	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2
3	TRNSP	CRUDE OIL TRANSPORT														
4	PIPE	PIPELINE	0000	0000	0000	0000	0000	0000	0000	8.00-02 5 2003	8.00-02 5	0000	0000	0000	1.72-01 3 2031	4.69+00 2
5	BARGE	BARGES	0000	0000	0000	0000	0000	0000	0000	7.65+00 2 2027	7.65+00 3	0000	0000	0000	3.02+00 2 2028	2.17+00 2
6	TRKTK	TANK TRUCKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.58-01 3 2029	1.07+01 3
7	TNKCR	TANK CARS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2030	3.84+00 2
8	PROCS	PROCESSING														
9	NAVHR	NATIONAL AVERAGE REFINERY	0000	0000	0000	0000	1.43+00 2 2006	3.58+01 3 2006	2.21+01 2 2006	6.00+00 2 2006	6.40+01 3	6.02+00 2 2006	2.02+01 2 2006	7.06+10 4 2006	8.10+00 3 2006	2.28+01 2
10	CRDTK	CRUDE OIL STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.30-02 3 2030	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2
11	DSALT	ELECTROSTATIC DESALTING	0000	0000	0000	0000	1.02+01 3 2005	2.23+01 3 2005	0000	1.50+00 3 2005	2.34+01 4	2.87-01 3 2005	2.65+00 3 2005	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2
12	DSTIL	ATMOS. & VAC. DISTILLATION	0000	0000	0000	0000	8.90-02 3 2006	1.12+00 3 2006	0000	1.60+00 3 2006	4.72+01 4	1.78-03 3 2006	4.45-01 3 2006	4.59+10 3 2006	2.87-01 3 2006	2.38+00 3
13	CATCR	CATALYTIC CRACKING	0000	0000	0000	0000	6.09+00 3 2007	1.52+01 3 2007	0000	5.24+00 3 2007	1.72+01 4	1.32+00 3 2007	1.58+00 3 2007	1.74+10 3 2007	5.68+00 3 2007	9.07+00 2
14	CATRF	CATALYTIC REFORMING	0000	0000	0000	0000	9.50-02 3 2008	1.19+01 3 2008	0.00+00 3 0007	4.62+00 3 2008	6.01+01 3	0.00+00 3 0007	2.83+00 3 2008	5.93+08 3 2008	3.32-01 3 2008	3.82+00 3
15	DSTHT	DISTILLATE HYDROTREATING	0000	0000	0000	0000	2.72+00 3 2009	3.01+00 3 2009	0.00+00 3 0007	3.60-04 3 2009	5.01+00 3	6.60-01 3 2009	4.30+00 3 2009	5.37+08 3 2009	1.46-02 3 2009	1.07-01 2
16	COKG	DELAYED COKING	0000	0000	0000	0000	0000	2.39+00 3 2010	0000	4.03-01 3 2010	2.68+00 3	0000	2.56+00 3 2010	1.72+10 3 2010	5.10-01 3 2010	5.87+00 3
17	DSTHC	DISTILLATE HYDROCRACKING	0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 3	3.72-01 3 2011	3.87+00 3 2011	1.43+10 3 2011	3.72-01 3 2011	3.13+00 3
18	ISOMR	ISOMERIZATION	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+08 3 2012	1.95-01 3 2012	1.13+01 3
19	ALKYL	ALKYLATION	0000	0000	0000	0000	2.32+00 3 2013	3.36+01 3 2013	0000	1.19+01 3 2013	3.36+01 4	1.19+00 3 2013	1.19+01 3 2013	1.04+11 3 2013	6.23-01 3 2013	9.50+00 3
20	AROMA	AROMATICS EXTRACTION	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
21	FURFR	FURFURAL REFINING	0000	0000	0000	0000	0000	0000	0000	2.45-01 3 2015	2.45-01 5	0000	0000	3.14+08 3 2015	5.42-01 3 2015	6.23+00 3
22	SLVDW	SOLVENT DEWAXING	0000	0000	0000	0000	0000	0000	0000	1.24-01 3 2016	1.24-01 5	2.06+01 3 2016	0000	7.90+10 3 2016	3.93-01 3 2016	6.32+00 3
23	SGTRT	SOUR GAS TREATING	0000	0000	0000	0000	0000	0000	0000	3.23+00 3 2018	3.25+00 5	6.23+00 3 2018	0000	6.43+08 3 2018	8.00-02 3 2018	9.70-02 3
24	GASTR	GASOLINE TREATING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3
25	LUBRO	LUBE OIL HYDROTREATING	0000	0000	0000	0000	2.64+00 3 2020	2.84+00 3 2020	0.00+00 3 0007	8.25-04 3 2020	2.88+00 3	8.25-01 3 2020	6.13+00 3 2020	2.78+10 3 2020	3.62-01 3 2020	4.16+00 3
26	GREAS	GREASE MANUFACTURE	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
27	WXLOS	WAX DEOILING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.37+10 3 2022	6.94-01 3 2022	7.52+00 3
28	PROPA	PROPANE DEASPHALTING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.07+10 3 2017	1.01+01 3 2017	1.16+01 3
29	H2MFG	HYDROGEN MANUFACTURING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.47+11 3 2023	4.45+00 3 2023	5.07+01 3
30	RFSTO	REFINERY PRODUCT STORAGE	0000	0000	0000	0000	0000	0000	0000	0000	0000	9.13-02 3 2037	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2
31	DSTRB	PRODUCT DISTRIBUTION														
32	PIPEL	PIPELINE	0000	0000	0000	0000	0000	0000	0000	8.22-02 3 2062	8.22-02 5	0000	0000	0000	1.72-01 3 2032	4.69+00 3
33	TANKR	TANKERS	0000	0000	0000	0000	0000	0000	0000	3.08+01 2 2063	3.08+01 2	0000	0000	0000	3.75-02 3 2033	3.37-01 3
34	SUPER	SUPERTANKERS	0000	0000	0000	0000	0000	0000	0000	3.08+01 2 2063	3.08+01 2	0000	0000	0000	3.13-02 3 2032	3.37-01 3
35	BARGE	BARGES	0000	0000	0000	0000	0000	0000	0000	7.86+00 2 2064	7.86+00 2	0000	0000	0000	3.02+00 3 2032	2.17+00 3
36	TNKTK	TANK TRUCKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.58-01 3 2032	1.07+01 3
37	TNKCR	TANK CARS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032	3.84+00 2
38	PTERM	PRODUCT TERMINALS														
39	TNKST	STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
40	MRKT	MARKETING														
41	GANT	AUTO GASOLINE TANK FILL	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
42																
43																
44																
45																
46																
47																
48																
49																
50																

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
		AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	ROW
0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.0000 2 0007	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0000	0.00+01 3 0000	0000	1
																	2
0000	0000	1.72+01 3 2031	4.00+00 3 2031	3.57+01 3 2031	6.00+01 3 2031	2.00+00 3 2031	7.00+02 3 2031	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	0000	3
0000	0000	3.02+00 3 2028	2.15+00 3 2028	2.31+01 3 2028	1.40+00 3 2028	1.00+00 3 2028	1.00+01 3 2028	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	3.10+00 2 2001	4
0000	0000	0.56+01 3 2029	1.47+01 3 2029	1.37+01 3 2029	1.67+00 3 2029	1.60+01 3 2029	3.04+01 3 2029	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	1.32+10 2 2003	5
0000	0000	1.28+00 3 2030	3.84+00 3 2030	3.33+00 3 2030	2.56+00 3 2030	3.56+00 3 2030	3.07+01 3 2030	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	1.10+10 3 2030	6
																	7
0 2006	7.00+10 6 2006	8.10+00 3 2006	2.20+01 3 2006	2.00+02 6 2006	2.02+02 3 2006	6.11+02 3 2006	2.73+00 3 2006	1.13+03 6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	8
0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	8.70+01 3 2006	0.00+00 2 0007	0.00+00 2 0007	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	9
0 2005	0.00+00 2 0007	2005	2005	2005	2005	2005	2005	2005	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	0.00+00 2 0007	10
0 2006	1.50+10 3 2006	2.35+01 3 2006	2.30+01 3 2006	4.21+01 3 2006	2.82+01 3 2006	6.14+03 3 2006	1.04+01 3 2006	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	11
0 2007	1.76+10 3 2007	5.68+00 3 2007	0.07+00 3 2007	2.78+01 3 2001	5.72+01 3 2007	1.21+03 3 2007	0.37+00 3 2007	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	12
0 2008	5.93+08 3 2008	3.32+01 3 2008	2.020+0 2 2008	0.07+03 3 2008	1.48+00 3 2008	6.65+03 3 2008	1.06+01 3 2008	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	13
0 2009	5.37+09 3 2009	1.46+02 3 2009	1.07+01 3 2009	4.37+04 3 2009	1.30+01 3 2009	2.91+04 3 2009	2.27+03 3 2009	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	14
0 2010	1.72+10 3 2010	5.26+01 3 2010	5.07+00 3 2010	1.06+02 3 2010	6.00+01 3 2010	1.04+02 3 2010	2.00+01 3 2010	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	15
0 2011	1.43+10 3 2011	2.72+01 3 2011	2.13+00 3 2011	8.10+03 3 2011	1.30+01 3 2011	5.44+01 3 2011	1.06+01 3 2011	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	16
0000	2.25+09 3 2012	1.45+01 3 2012	1.13+01 3 2012	5.83+03 3 2012	1.34+01 3 2012	3.88+03 3 2012	9.72+02 3 2012	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	17
0 2013	1.04+11 3 2013	8.25+01 3 2013	9.50+00 3 2013	2.46+03 3 2013	5.11+01 3 2013	1.63+02 3 2013	4.13+01 3 2013	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	18
0000	4.16+10 3 2014	0000	0000	0000	1.61+01 3 2014	0000	0000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	19
0000	3.44+10 3 2015	5.42+01 3 2015	6.23+00 3 2015	1.62+02 3 2015	7.21+00 3 2015	1.08+02 3 2015	2.71+01 3 2015	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	0000	20
0000	7.90+10 3 2016	1.30+01 3 2016	6.32+00 3 2016	[illegible] 3 2016	1.90+01 3 2016	7.10+02 3 2016	2.76+01 3 2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	21
0000	6.43+00 3 2019	8.30+03 3 2018	9.70+02 3 2018	[illegible] 3 2018	4.00+01 3 2018	1.68+04 3 2018	4.00+03 3 2018	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	22
0000	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3 2019	0.00+00 3 2019	0.00+00 3 2019	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	23
0 2020	2.76+10 3 2020	3.42+01 3 2020	4.16+00 3 [illegible]	1.12+02 3 2020	1.36+01 3 2020	7.27+03 3 2020	1.81+01 3 2020	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	24
0000	0000	0000	0000	0000	9.94+00 4 2021	0000	0000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	0000	25
0000	3.77+10 3 2022	6.34+01 3 2022	[illegible] 3 2022	1.07+02 2022	1.19+01 3 2022	1.31+02 3 2022	3.27+01 3 2022	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	26
0000	4.37+10 3 2017	[illegible] 3 2017	[illegible] 3 2017	3.03+02 3 2017	[illegible] 3 2017	2.02+02 3 2017	3.34+01 3 2017	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	27
0000	2.47+11 3 2023	6.45+00 3 2023	6.07+01 3 2023	1.43+01 3 2023	0.89+00 3 2023	0.89+02 3 2023	7.46+00 3 2023	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	28
0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	4.33+01 3 2037	0.00+00 2 0007	0.00+00 2 0007	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	0.00+00 2 0007	29
																	30
0000	0000	1.72+01 3 2032	4.00+00 3 2032	3.57+01 3 2032	4.00+01 3 2032	2.00+00 3 2032	7.04+02 3 2032	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	31
0000	0000	3.75+02 3 2032	3.37+01 3 2032	5.15+01 3 2032	1.90+02 3 2032	6.14+03 3 2032	[illegible]	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	32
0000	0000	2.75+02 3 2032	3.37+01 3 2032	5.15+01 3 2032	1.90+02 3 2032	6.14+03 3 2032	[illegible]	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	33
0000	0000	3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032	1.40+00 3 2032	1.00+00 3 2032	[illegible]	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	34
0000	0000	6.56+01 3 2032	1.47+01 3 2032	1.37+00 3 2032	1.67+00 3 2032	1.16+01 3 2032	[illegible]	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	35
0000	0000	1.28+00 3 2032	3.84+00 3 2032	3.33+00 3 2032	2.56+00 3 2032	3.56+00 3 2032	[illegible]	[illegible]	0000	[illegible]	[illegible]	[illegible]	[illegible]	2001	[illegible]	[illegible]	36
																	37
0000	0000	0000	0000	0000	3.84+01 3 2038	0000	0000	3.50+01 3	0000	[illegible]	[illegible]	[illegible]	[illegible]	2000	[illegible]	[illegible]	38
																	39
0000	0000	0000	0000	0000	4.80+01 3 2039	0000	0000	4.00+01 3	0000	0000	0000	0000	0000	2000	0.00+01 2 2000	0.00+00 2 0007	40
																	41
																	42
																	43
																	44
																	45
																	46
																	47
																	48
																	49
																	50

TABLE 15. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED DOMESTIC ON-SHORE REGION OF OIL SUPPLY

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2200

BASED ON(2018,59), DOMESTIC ONSHORE OIL HAS AN AVERAGE SULFUR CONTENT OF 0.81PC.USING THE NATIONAL AVERAGE OF 0.79PC(FROM FOOTNOTE 2000) AS A STANDARD, THE ONSHORE PRODUCED OIL CONTAINS 2.5P MORE SULFUR. FUEL OIL FROM THIS CRUDE WOULD CONTAIN ABOUT 1.54PC S & PETROLEUM COKE WOULD CONTAIN ABOUT 1.85PC S.THE SOX EMISSIONS FROM THE CATALYTIC CRACKING OPERATION, AND FROM THE BURNING OF FUEL OIL, PETROLEUM COKE AND REFINERY GASES WILL INCREASE BY 2.5PC. THESE INCREASES ARE

CAT. CRACKER SOX 3.33E-01 TONS/YR
FUEL OIL COMBUSTION 2.08E-01
REFINERY GAS COMBUSTION 5.08E+00
PETROLEUM COKE COMBUSTION 3.90E-01

2201

SOX EMISSIONS WILL INCREASE BY 2.5P ABOVE THOSE FROM FOOTNOTE 2007(SEE FOOTNOTE 2200). THIS ADDITIONAL SOX EMISSION AMOUNTS TO 6.58E-01 TONS/YR.

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		CONTROLLED FUEL: OIL	CONTROLLED REGION: DOMESTIC OIL SHALE	1	2	3	4	5	6	7	8	9	10	11	12	13	14
				WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL 12)													
						DISSOLVED SOLIDS											
ROW	SYMBOL	ACTIVITY PROCESS		ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12}BTU)	PARTICULATES	NO_x
1	EXTR	EXTRACTION															
2	ONSH	ONSHORE PRODUCTION		0000	0000	0000	0000	0000	0000	0000	1.55-01 3 2004	1.55-01 3	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 3 [illegible]
3	TRNSP	CRUDE OIL TRANSPORT															
4	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	8.00-02 3 2003	8.00-02 3	0000	0000	0000	1.72-01 3 2031	6.00+00 3 [illegible]
5	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.05+00 2 2027	7.05+00 3	0000	0000	0000	3.02+00 3 2020	2.17+00 3 [illegible]
6	TRKTK	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.58-01 3 2020	1.07+01 3 [illegible]
7	TRKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2030	3.84+00 3 [illegible]
8	PROCS	PROCESSING															
9	NAVRE	NATIONAL AVERAGE REFINERY		0000	0000	0000	0000	3.65-01 2 2100	3.65+01 5 2100	6.04-01 2 2100	3.00-01 2 2100	9.00+01 5	0.94-01 2 2100	4.94+00 2 2100	0.00+00 2 2103	2.73+00 3 2171	1.07+01 3 [illegible]
10	CRUTK	CRUDE OIL STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00-02 3 2036	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 [illegible]
11	DSALT	ELECTROSTATIC DESALTING		0000	0000	0000	0000	1.02+01 3 2005	2.23+01 3 2005	0000	1.07+00 3 2005	2.34+01 4	3.07-01 3 2005	2.95+00 3 2005	0.00+00 2 0007	2005	[illegible]
12	DSTIL	ATMOS. & VAC. DISTILLATION		0000	0000	0000	0000	6.90-02 3 2006	3.12+00 3 2006	0000	1.60+00 3 2006	4.72+00 4	1.76-02 3 2006	4.45-01 3 2006	1.50+10 3 2006	2.07-01 3 2006	2.36+00 3 [illegible]
13	CATCR	CATALYTIC CRACKING		0000	0000	0000	0000	6.49+00 3 2007	7.02+00 3 2007	0000	9.24+00 3 2007	1.72+01 4	1.32+00 3 2007	1.58+00 3 2007	1.74+10 3 2007	1.90+00 3 2107	0.07+00 3 [illegible]
14	CATRF	CATALYTIC REFORMING		0000	0000	0000	0000	0.50-02 3 2008	1.19+01 3 2008	0.00+00 3 0007	4.82+00 3 2008	6.01+00 3	0.00+00 3 0007	3.80+00 3 2008	5.93+08 3 2008	3.32-01 3 2008	3.82+00 3 [illegible]
15	DSTRT	DISTILLATE HYDROTREATING		0000	0000	0000	0000	8.72+00 3 2009	3.01+00 3 2009	0.00+00 3 0007	6.00-04 3 2009	3.01+00 3	0.60-01 3 2009	4.30+08 3 2009	8.37+08 3 2009	1.46-02 3 2009	1.67-01 3 [illegible]
16	COKING	DELAYED COKING		0000	0000	0000	0000	0000	2.39+00 3 2010	0000	4.93-01 2 2010	2.88+00 3	0000	2.54+00 3 2010	1.72+10 3 2010	5.20-01 3 2010	5.97+00 3 [illegible]
17	DSTRC	DISTILLATE HYDROCRACKING		0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 5	1.72-01 3 2011	3.07+04 3 2011	1.43+10 3 2011	2.72-01 3 2011	3.13+00 3 [illegible]
18	ISOMR	ISOMERIZATION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+09 3 2012	1.85-01 3 2012	1.13+01 3 [illegible]
19	ALKYL	ALKYLATION		0000	0000	0000	0000	2.27+00 3 2013	3.56+01 3 2013	0000	1.19-02 3 2013	3.56+01 4	1.19+00 3 2013	1.19+01 3 2013	1.04+11 3 2013	8.25-01 3 2013	8.50+00 3 [illegible]
20	AROM	AROMATICS EXTRACTION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.18+10 3 2014	0000	[illegible]
21	FURFR	FURFURAL REFINING		0000	0000	0000	0000	0000	0000	0000	2.48-01 3 2015	2.48-01 3	0000	0000	3.44+10 3 2015	5.42-01 3 2015	6.22+00 3 [illegible]
22	SL-DEW	SOLVENT DEWAXING		0000	0000	0000	0000	0000	0000	0000	1.24-01 3 2016	1.24-01 3	2.06-01 3 2016	0000	7.00+10 3 2016	8.50-01 3 2016	6.32+00 3 [illegible]
23	SGTR	SOUR GAS TREATING		0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2018	1.25+00 3	8.23+00 3 2018	0000	6.43+08 3 2018	6.00-02 3 2018	8.20-01 3 [illegible]
24	GASTR	GASOLINE TREATING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2018	0.00+00 3 2018	0.00+00 3 [illegible]
25	LUBRC	LUBE OIL HYDROTREATING		0000	0000	0000	0000	2.04+00 2 2020	2.00+00 3 2020	0.00+00 3 0007	8.25-04 3 2020	3.08+00 3	8.25-01 3 2020	4.12+00 3 2020	2.78+10 3 2020	3.02-01 3 2020	4.10+00 3 [illegible]
26	GREAS	GREASE MANUFACTURE		[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible]
27	WXDOL	WAX DEOILING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.94-01 3 2022	7.52+00 3 [illegible]
28	PROPA	PROPANE DEASPHALTING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.97+10 3 2017	1.81+00 3 2017	1.10+01 3 [illegible]
29	HDRGN	HYDROGEN MANUFACTURING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.47-11 3 2023	4.45+00 3 2023	5.07+01 3 [illegible]
30	RFSTO	REFINERY PRODUCT STORAGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.10-02 3 2027	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 3 [illegible]
31	DSTR	PRODUCT DISTRIBUTION															
32	PIPAL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	8.22-02 3 2002	8.22-02 5	0000	0000	0000	1.72-01 3 2032	6.00+00 3 [illegible]
33	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	8.07+00 2 2127	8.07+00 3	0000	0000	0000	3.75-02 3 2037	3.37-01 3 [illegible]
34	SUPTR	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	8.07+00 2 2127	8.07+00 3	0000	0000	0000	3.75-02 3 2037	3.37-01 3 [illegible]
35	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.06+00 2 2004	7.06+00 3	0000	0000	0000	3.02+00 3 2032	2.17+00 3 [illegible]
36	TRKTK	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.58-01 3 2032	1.07+01 3 [illegible]
37	TRKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032	3.84+00 3 [illegible]
38	PTERM	PRODUCT TERMINALS															
39	TKSTT	STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
40	MRKT	MARKETING															
41	GAST	AUTO GASOLINE TANK FILL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00	0000	0000	0000	
42																	
43																	
44																	
45																	
46																	
47																	
48																	
49																	
50																	

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12} BTU)	PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	ROW
																1
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0000	1.03+00 2 2001	6.20-05 4 2033	3.75-03 4 2033	1.28-01 4 2033	2000	3.00-01 2 2000	0000	2
																3
0000	1.72-01 3 2031	4.80+00 3 2031	3.07-01 3 2031	6.96-01 3 2031	2.06+00 3 2031	7.86-02 3 2031	8.07+00 3	0000	6.30-01 2 2002	3.30-05 4 2034	2.70-03 4 2034	9.45-02 4 2034	2007	1.00+00 2 2001	3.40+00 2 2041	4
0000	3.32+00 3 2020	2.17+00 3 2020	2.21+00 3 2020	1.40+00 3 2020	1.06+00 3 2020	1.09-01 3 2020	1.09+01 3	0000	1.01-01 3 2071	0000	0000	0000	2000	1.00+00 2 2003	2.53+10 2 2003	5
0000	8.58-01 3 2020	1.07+01 3 2020	1.37+00 3 2020	1.07+00 3 2020	1.14+01 3 2020	3.04-01 3 2020	2.43+01 3	0000	3.52+02 3 2007	0000	0000	0000	2000	0000	1.30+10 2 2020	6
0000	1.68+00 3 2030	3.84+00 3 2030	2.32+00 3 2020	2.96+00 3 2020	3.59+00 3 2020	5.60-01 3 2030	1.52+01 3	0000	1.00+01 3 2070	0000	0000	0000	2000	0000	1.42+10 2 2020	7
																8
0.00+00 2 2103	2.73+00 3 2101	1.97+01 3 2101	2.13+01 3 2101	2.38+01 3 2101	1.89-01 3 2101	3.71+00 3 2101	7.12+01 3	4.37+01 4 2101	1.03+01 4 2103	4.30-04 2 2041	2.03-02 2 2041	2.05+00 2 2041	2001	0.00-01 2 2000	0.00+10 2 2130	9
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 2123	0.00+00 2 0007	0.00+00 2 0007	0.00+00 3	0000	1.01-01 3 2071	0000	0000	0000	2003	1.00+00 2 2123	0.00+00 2 0007	10
0.00+00 3 0007	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.00+07 2 2040	11
1.50+10 3 2006	2.07-01 3 2006	2.38+00 3 2006	6.21-02 3 2006	2.09+00 3 2100	4.14-02 3 2006	1.04-01 3 2006	5.09+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	2.21+10 2 2000	12
1.70+10 3 2007	1.50+00 3 2107	8.07+00 3 2107	2.70+01 3 2101	3.98+00 3 2107	2.70-01 3 2107	6.57+00 3 2107	4.83+01 3	6.17+00 3 2107	0000	0000	0000	0000	2001	1.00+00 2 2070	3.81+10 2 2107	13
5.92+00 3 2006	3.12-01 3 2006	3.52+00 3 2006	9.07-03 3 2006	2.00+00 3 2100	6.03-03 3 2006	1.16-01 3 2006	7.28+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.35+10 2 2000	14
8.27+00 3 2005	1.46-02 3 2000	1.07-01 3 2000	4.37-04 3 2000	2.00+00 3 2100	2.21-04 3 2000	7.27-03 3 2000	7.47+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.30+00 2 2000	15
1.72+10 3 2010	5.20-01 3 2010	5.07+00 3 2010	1.50-07 3 2010	2.77+00 3 2110	1.06-02 3 2010	7.60-01 3 2010	8.00+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	6.17+10 2 2010	16
1.43+10 3 2011	2.72-01 3 2011	3.13+00 3 2011	6.16-03 3 2011	2.03+00 3 2111	5.44-03 3 2011	1.20-01 3 2011	6.17+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.50+10 2 2011	17
2.25+00 3 2012	1.85-01 3 2012	1.13+01 3 2012	6.02-03 3 2012	2.07+00 3 2112	3.00-03 3 2012	6.72-03 3 2012	1.08+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	2.53+10 2 2012	18
1.04+11 1 2013	0.30-01 3 2013	0.50+00 3 2013	2.49-01 3 2013	0.00+00 3 2113	1.65-02 3 2013	4.13-01 3 2013	1.03+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0.00+10 2 2013	19
6.10+10 3 2014	0000	0000	0000	2.04+00 3 2114	0000	0000	2.04+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	20
3.46+10 3 2015	5.62-01 3 2015	6.23+00 3 2015	1.02-02 3 2015	2.00+00 3 2115	1.08-02 3 2015	2.71-01 3 2015	1.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	5.75+10 2 2015	21
7.00+10 3 2016	6.50-01 3 2016	0.32+00 3 2016	1.03-02 3 2016	2.10+00 3 2116	1.10-02 3 2016	2.74-01 3 2016	1.04+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	7.00+10 2 2016	22
6.43+00 3 2018	9.00-02 3 2018	9.20-02 3 2018	2.02-04 3 2014	4.04+00 3 2118	1.00-04 3 2018	4.00-03 3 2018	4.16+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.07+00 2 2018	23
0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	3.07+00 3 2119	0.00+00 3 2019	0.00+00 3 2019	2.47+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	24
2.70+10 3 2020	3.02-01 3 2020	4.10+00 3 2020	1.12-02 3 2020	2.71+00 3 2120	7.23-03 3 2020	1.01-01 3 2020	7.63+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.52+10 2 2020	25
0000	0000	0000	0000	2.03+00 3 2121	0000	0000	2.03+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	26
3.77+10 3 2022	6.56-01 3 2022	7.52+00 3 2022	1.07-02 3 2022	2.02+00 3 2122	1.31-02 3 2022	3.17-01 3 2022	4.10+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0.61+10 2 2022	27
6.07+10 3 2017	1.01+00 3 2017	1.10+01 3 2017	2.02-02 3 2017	2.48+00 3 2117	2.02-02 3 2017	3.04-01 3 2017	1.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.00+11 2 2017	28
3.47+11 3 2023	4.45+00 3 2023	5.67+01 3 2023	1.49-01 3 2023	5.89+00 3 2123	9.89-02 3 2023	2.46+00 3 2023	7.38+01 3	0000	0000	0000	0000	0000	2001	5.03-01 2 2070	0.00+00 2 2070	29
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3 2124	0.00+00 3 0007	0.00+00 2 0007	7.30+00 3	0000	1.00-01 3 2071	0000	0000	0000	2003	1.00+00 2 2124	0.00+00 2 0007	30
																31
0000	1.72-01 3 2032	4.80+00 3 2032	3.07-01 3 2032	6.96-01 3 2032	2.06+00 3 2032	7.86-02 3 2032	8.07+00 3	0000	2.70+01 2 2000	0.00-05 3 2032	4.28-03 3 2032	1.00-01 3 2032	2007	1.00+00 2 2001	3.00+00 2 2001	32
0000	3.75-02 3 2032	3.37-01 3 2032	5.10-01 3 2032	1.00-02 3 2032	6.16-03 3 2032	3.30-03 3 2032	5.18-01 3	0000	1.00-01 3 2071	0000	0000	0000	2003	1.00+00 2 2127	4.07+10 2 2002	33
0000	3.75-02 3 2032	3.37-01 3 2032	5.10-01 3 2032	1.00-02 3 2032	6.16-03 3 2032	3.30-03 3 2032	5.18-01 3	0000	1.00-01 3 2071	0000	0000	0000	2003	1.00+00 2 2127	4.07+10 2 2002	34
0000	3.02+00 3 2032	2.17+00 3 2032	2.21+00 3 2032	1.40+00 3 2032	1.06+00 3 2032	1.09-01 3 2032	1.09+01 3	0000	1.00-01 3 2071	0000	0000	0000	2003	1.00+00 2 2002	2.57+10 2 2002	35
0000	8.58-01 3 2032	1.07+01 3 2032	1.37+00 3 2032	1.07+00 3 2032	1.14+01 3 2032	3.04-01 3 2032	2.43+01 3	0000	3.52+02 3 2002	0000	0000	0000	2003	0000	1.41+10 2 2020	36
0000	1.68+00 3 2032	3.84+00 3 2032	2.32+00 3 2032	2.96+00 3 2032	3.59+00 3 2032	5.60-01 3 2032	1.52+01 3	0000	1.00+01 3 2000	0000	0000	0000	2003	0000	1.46+10 2 1*30	37
																38
0000	0000	0000	0000	1.00+00 2 2130	0000	0000	1.00+00 2 2130	0000	1.72-01 2 2001	0000	0000	0000	2000	1.00+00 2 2130	0.00+00 2 0007	39
																40
0000	0000	0000	0000	0.00+00 2 2130	0000	0000	0.00+00 2 2130	0000	0000	0000	0000	0000	2000	1.00+00 2 2130	0.00+00 2 0007	41
																42
																43
																44
																45
																46
																47
																48
																49
																50

TABLE 16. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED DOMESTIC ON-SHORE REGION OF OIL SUPPLY

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2300

BASED ON (2018,59), DOMESTIC ONSHORE OIL HAS AN AVERAGE SULFUR CONTENT OF 0.81 PC. BASED ON 3.2 PC OF THE S IN THE CRUDE BEING DISCHARGED FROM THE CAT CRACKER REGENERATOR (FOOTNOTE 2107), THE CAT CRACKING SO2 EMISSION FOR A 178000 BBL/YR REFINERY (1.0E12 BTU/YR) IS 13.65 TON SO2/YR. BASED ON 48.8 PC OF THE S IN THE CRUDE AS H2S IN THE REFINERY PROCESS GAS (FOOTNOTE 2066), WITH .3 TON S EMITTED IN THE COMBUSTION OF THIS PROCESS GAS (FOOTNOTE 2101), AND WITH A 99.9 PC RECOVERY OF THE S IN THE PROCESS GAS SENT TO THE CLAUS PLANT AND TAIL-GAS UNIT (FOOTNOTE 2101), .21 TON OF SO2 ARE DISCHARGED YEARLY FROM THE CLAUS UNIT. FUEL COMBUSTION SO2 EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2101 AND ARE LIMITED BY REGULATIONS.

2301

FROM FOOTNOTE 2300, THE CAT CRACKER SO2 EMISSION FOR A 1.0E12 BTU/YR REFINERY IS 13.65 TON SO2/YR. FOR 1.0E12 BTU/YR INPUT TO THE CAT CRACKER MULTIPLY THIS BY 1.98 (FOOTNOTE 2107).

		(UNCONTROLLED) FUEL	REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
		OIL	DOMESTIC OFF SHORE	WATER POLLUTANTS (TONS/10^{12} BTU, EX COL 12)													
ROW	MNE-MON	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS PO_4	DISSOLVED SOLIDS NO_3	DISSOLVED SOLIDS OTHER	DISSOLVED SOLIDS TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12}BTU	PARTIC-ULATES	NO_x
1	EXTRC	EXTRACTION															
2	OFSHR	OFFSHORE PRODUCTION		0000	0000	0000	0000	0000	0000	0000	1.20-00 3 2035	1.20+00 3	0000	0000	6.06+00 2 0007	0.00+00 2 0007	6.00+00 2
3	TRNSP	CRUDE OIL TRANSPORT															
4	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	6.00-02 5 2003	6.00-02 5	0000	0000	0000	1.72-01 3 2031	4.00+00 3
5	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.65+00 2 2027	7.65+00 3	0000	0000	0000	3.02+03 3 2028	2.17+00 3
6	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.58-01 3 2029	1.87+01 3
7	TNKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2030	3.84+00 3
8	PROCS	PROCESSING															
9	NAVRF	NATIONAL AVERAGE REFINERY		0000	0000	0000	0000	1.43+00 2 2006	3.58+01 3 2006	2.22+01 2 2006	6.00+00 2 2006	6.46+01 3	6.62+00 2 2006	2.02+01 2 2006	7.06+10 4 2006	9.10+06 3 2006	[illegible]
10	CRDTK	CRUDE OIL STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	6.90-02 3 2030	0000	6.00+00 2 0007	5.00+00 2 0007	5.00+00 2
11	DSALT	ELECTROSTATIC DESALTING		0000	0000	0000	0000	1.02+01 3 2005	2.23+01 3 2005	0000	7.07+00 3 2005	2.34+01 4	2.67+01 3 2005	2.85+00 3 2005	6.00+00 2 0007	2005	
12	DSTIL	ATMOS. & VAC. DISTILLATION		0000	0000	0000	0000	6.00-02 3 2006	3.12+00 3 2006	0000	1.60+00 3 2006	4.72+00 4	1.78-02 3 2006	4.45-01 3 2006	1.30+10 3 2006	2.07-01 3 2006	3.00+00 3
13	CATCR	CATALYTIC CRACKING		0000	0000	0000	0000	6.65+00 3 2007	7.62+00 3 2007	0000	9.24+00 3 2007	1.72+01 4	1.32+00 3 2007	1.56+00 3 2007	1.74+11 3 2007	5.68+00 3 2007	9.07+00 3
14	CATRF	CATALYTIC REFORMING		0000	0000	0000	0000	9.50-02 3 2008	1.58+01 3 2008	0.00+00 3 0007	4.02+00 3 2008	8.01+00 3	0.00+00 3 0007	3.60+03 3 2008	5.93+09 3 2008	3.32+11 3 2008	3.42+0 3
15	DSTHT	DISTILLATE HYDROTREATING		0000	0000	0000	0000	2.72+00 3 2009	3.01+00 3 2009	0.00+00 3 0007	8.+2.04 3 2009	3.01+00 3	8.00-01 3 2009	4.30+00 3 2009	5.37+09 3 2009	1.46-02 3 2009	1.67-01 3
16	COKG	DELAYED COKING		0000	0000	0000	0000	0000	3.39+05 3 2010	0000	1.51-01 3 2010	2.50+00 3	0000	2.54+00 3 2010	1.72+10 3 2010	5.20-01 3 2010	3.87+00 3
17	DSTHC	DISTILLATE HYDROCRACKING		0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 3	1.72-01 3 2011	3.87+00 3 2011	1.43+10 3 2011	2.72-01 3 2011	3.13+00 3
18	ISOMR	ISOMERIZATION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+08 3 2012	1.90-01 3 2012	1.13+01 3
19	ALKYL	ALKYLATION		0000	0000	0000	0000	2.07+00 3 2013	3.50+01 3 2013	0000	10.02 3 2013	3.50+01 4	1.19+00 3 2013	1.19+01 3 2013	1.04+11 3 2013	6.25-01 3 2013	9.30+00 3
20	AROM	AROMATICS EXTRACTION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.16+10 3 2014	0000	
21	FURFR	FURFURAL REFINING		0000	0000	0000	0000	0000	0000	0000	2.46-01 3 2015	2.46-01 3	0000	0000	3.44+10 3 2015	5.42-01 3 2015	6.23+00 3
22	SLDWX	SOLVENT DEWAXING		0000	0000	0000	0000	0000	0000	0000	1.26-01 3 2016	1.26-01 3	2.06+01 3 2016	0000	7.90+10 3 2016	5.50-01 3 2016	6.30+00 3
23	SGTRT	SOUR GAS TREATING		0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2017	1.25+00 3	6.23+00 3 2016	0000	6.43+00 3 2016	8.00-03 3 2016	9.20-02 3
24	GASTR	GASOLINE TREATING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2019	0.00+00 3 2019	0.00+00 4
25	LUBES	LUBE OIL HYDROTREATING		0000	0000	0000	0000	2.04+00 3 2020	2.04+00 3 2020	0.00+00 3 0007	8.25-04 3 2020	2.09+00 3	8.25-01 3 2020	6.13+00 3 2020	3.70+10 3 2020	3.02-01 3 2020	4.10+00 3
26	GREAS	GREASE MANUFACTURE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
27	WXDOL	WAX DEOILING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.14-01 3 2022	7.52+00 3
28	PROPA	PROPANE DEASPHALTING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.97+10 3 2017	1.01+00 3 2017	1.18+01 3
29	HZMFG	HYDROGEN MANUFACTURING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.47+11 3 2021	4.45+00 3 2021	5.67-01 3
30	RFSTO	REFINERY PRODUCT STORAGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	9.15-02 3 2037	0000	0.00+00 2 0007	0.00+00 2 0007	0.00-02
31	DISTR	PRODUCT DISTRIBUTION															
32	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	6.22-02 5 2003	6.22-02 5	0000	0000	0000	1.72-01 3 2032	4.00+00 3
33	TANKS	TANKERS		0000	0000	0000	0000	0000	0000	0000	3.00+01 2 2003	1.00+01 2	0000	0000	0000	3.75-02 3 2032	3.37-01 3
34	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	3.00+01 2 2003	3.00+01 2	0000	0000	0000	3.75-02 3 2032	3.37-01 3
35	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.00+00 2 2004	7.00+00 2	0000	0000	0000	3.02+03 3 2032	2.17+00 3
36	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.58-01 3 2032	1.87-01 3
37	TNKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032	3.84+00 3
38	PTERM	PRODUCT TERMINALS															
39	TNKST	STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
40	MRKT	MARKETING															
41	GAST	AUTO GASOLINE TANK FILL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
42																	
43																	
44																	
45																	
46																	
47																	
48																	
49																	
50																	

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12}BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12}BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12}BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12}BTU)	ROW
0000 6.46+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0000	3.54-01 2 2061	5.70-06 4 2032	3.61-04 4 2033	4.88-03 4 2033	2000	3.00-01 3 2000	0000	1
0000 0000	1.72-01 3 2031	4.69+00 3 2031	3.37-01 3 2031	4.90-01 3 2031	2.96+00 3 2031	7.94-02 3 2031	8.87+00 3	0000	8.36+01 2 2002	3.30-0[illegible] 4 2034	2.79-03 4 2034	6.46-02 4 2034	0987	1.00+00 2 2081	3.39+00 2 2081	2
0000 0000	3.02+00 3 2028	2.17+00 3 2028	2.31+00 3 2028	1.40+00 3 2028	1.80+00 3 2028	1.09+01 3 2028	1.09+01 3	0000	1.61-01 3 2071	0000	0000	0000	2000	1.00+00 2 2083	2.52+10 2 2083	3
0000 0000	6.58-01 3 2029	1.67+01 3 2029	1.37+00 3 2029	1.87+00 3 2029	1.14+01 3 2029	3.04-01 3 2029	3.43+01 3	0000	3.52+02 3 2067	0000	0000	0000	2000	0000	1.38+10 2 2029	4
0000 0000	1.20+00 3 2030	3.84+00 3 2030	1.33+00 3 2030	2.56+00 3 2030	3.59+00 3 2030	5.60-01 3 2030	1.52+01 3	0000	1.98+01 3 2070	0000	0000	0000	2000	0000	1.42+10 2 2030	5
2 2006 7.46+10 4 2064	9.10+00 3 2006	2.28+01 3 2006	1.01+02 4 2203	1.32+02 3 2068	6.11+02 3 2066	3.73+00 3 2066	1.06+03 6	2.62+06 5 2000	1.03+01 4 2040	4.35-04 3 2041	3.62-02 3 2041	2.05+00 3 2041	2001	0.32-01 3 2003	5.00+10 2 2004	6
0000 0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	6.72+01 3 2036	0.00+00 2 0997	0.00+00 2 0997	6.72+01 3	0000	1.61-01 3 2071	0000	0000	0000	2002	0.84+01 2 2060	0.[illegible]+00 2 0997	7
2 2005 0.00+00 2 0997	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	1.00+07 2 2005	8
2 2006 1.30+10 3 2006	2.07-01 3 2004	2.38+00 3 2004	6.21-03 3 2006	2.82+01 3 2006	4.14-03 3 2006	1.04-01 3 2006	3.09+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	2.21+10 2 2006	9
2 2007 1.74+10 3 2007	5.68+00 3 2007	8.02+00 3 2007	1.86+01 4 2203	3.72+01 3 2007	1.21+03 3 2007	6.57+00 3 2007	1.78+03 4	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	3.35+10 2 2007	10
2 2008 5.93+09 3 2008	3.32-01 3 2008	3.82+00 3 2008	8.97-01 3 2008	1.46+00 3 2008	6.65-01 3 2008	1.36-01 3 2008	1.81+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	4.35+10 2 2008	11
2 2009 3.37+09 3 2009	1.46-02 3 [illegible]	1.67-01 3 2009	4.37-04 3 2009	1.36+01 3 2009	2.91-04 3 2009	7.27-02 3 2009	1.40-03 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	1.59+09 2 2009	12
2 2010 1.72+10 3 2010	5.28-01 3 2010	5.97+00 3 2010	1.36-02 3 2010	6.06+01 3 2010	1.04-02 3 2010	2.50-01 3 2010	1.74-01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	6.17+10 2 2010	13
2 2011 1.43+10 3 2011	2.72-01 3 2011	3.13+00 3 2011	8.10-03 3 2011	1.30+01 3 2011	5.44-03 3 2011	1.36-01 3 2011	1.06-01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	4.56+10 2 2011	14
0000 2.25+09 3 2012	1.95-01 3 2012	1.13+01 3 2012	5.85-03 3 2012	1.34+01 3 2012	3.68-03 3 2012	9.72-02 3 2012	2.50-01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	2.32+10 2 2012	15
2 2013 1.14+11 3 2013	6.25-01 3 2013	8.30+00 3 2013	2.48-03 3 2013	5.11+01 3 2013	1.65-02 3 2013	4.13-01 3 2013	8.18+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	8.90+10 2 2013	16
0000 4.16+10 3 2014	0000	0000	0000	1.61+01 3 2014	0000	0000	1.61+01 5	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	0000	17
0000 3.46+10 3 2015	5.42-01 3 2015	6.23+00 3 2015	1.62-02 3 2015	7.21+00 3 2015	1.08-02 3 2015	2.71-01 3 2015	2.13-01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	5.75+10 2 2015	18
2 2016 7.83+10 3 2016	5.50-01 3 2016	6.32+00 3 2016	1.65-02 3 2016	1.90+01 3 2016	1.10-02 3 2016	2.74-01 3 2016	7.62+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	7.60+10 2 2016	19
0000 [illegible] 3 2018	8.00-03 3 2018	9.29-02 3 2018	2.40-04 3 2018	4.00+01 3 2018	1.60-04 3 2018	4.00-03 3 2018	4.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	1.87+09 2 2016	20
0000 0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	0000	21
2 2020 2.78+10 3 2020	3.82-01 3 2020	4.15+00 3 2020	1.12-02 3 2020	1.38+01 3 2020	7.23-03 3 2020	1.81-01 3 2020	1.65+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	4.12+10 2 2020	22
0000 0000	0000	0000	0000	9.94+00 4 2021	0000	0000	9.94+00 5 2065	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	0000	23
0000 3.75+10 3 2022	6.34-01 3 2022	7.32+00 3 2022	1.87-02 3 2022	1.19+01 3 2022	1.31-02 3 2022	2.27-01 3 2022	2.66+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	6.61+10 2 2022	24
0000 6.87+10 3 2017	1.81+00 3 2017	1.18+01 3 2017	3.00-02 3 2017	1.11+01 3 2017	2.02-02 3 2017	5.04-01 3 2017	2.63+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2076	1.08+11 2 2017	25
0000 2.47-11 3 2023	4.45+00 3 2023	5.67+01 3 2023	1.49-01 3 2023	9.89+00 3 2023	9.80-02 3 2023	2.48-00 3 2023	7.38-01 3	0000	0000	0000	0000	0000	2001	1.03-01 2 2078	1.01+12 2 2078	26
0000 0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	0.00+00 2 0997	9.33+01 3 2037	0.00+00 2 0997	0.00+00 2 0997	9.33+01 3	0000	1.66-01 1 2071	0000	0000	0000	2002	0.88-01 2 2060	0.00+00 2 0997	27
																28
																29
																30
0000 0000	1.72-01 3 2032	4.69+00 3 2032	3.37-01 3 2032	4.90-01 3 2032	2.96+00 3 2032	7.94-02 3 2032	8.87+00 3	0000	1.79+01 2 2060	0.00-05 3 2042	4.26-03 2 2042	3.00-01 2 2042	2087	2.00+00 2 2081	3.60+09 2 2081	31
0000 0000	3.15-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.90-02 3 2032	6.14-03 3 2032	3.15-03 3 2032	1.18-01 3	0000	1.66-01 3 2071	0000	0000	0000	2000	0.00-01 2 2062	4.07+10 2 2062	32
0000 0000	3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.90-02 3 2032	6.14-03 3 2032	3.15-03 3 2032	1.18-01 3	0000	1.66-01 3 2071	0000	0000	0000	2000	0.00-01 2 2062	4.07+10 2 2062	33
0000 0000	3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032	1.60+00 3 2032	1.80+00 3 2032	1.09-01 3 2032	1.09+01 3	0000	1.66-01 3 2071	0000	0000	0000	2000	1.00+00 2 2063	2.57+10 2 2063	34
0000 0000	6.58-01 3 2032	1.67+01 3 2032	1.37+00 3 2032	1.87+00 3 2032	1.14+01 3 2032	3.04-01 3 2032	3.43+01 3	0000	3.63+02 3 2067	0000	0000	0000	2000	0000	1.41+10 3 2030	35
0000 0000	1.20+00 3 2032	3.84+00 3 2032	3.23+00 3 2032	2.56+00 3 2032	3.59+00 3 2032	5.60-01 3 2032	1.52+01 3	0000	1.98+01 3 2069	0000	0000	0000	2000	0000	1.48+10 2 2030	36
																37
																38
0000 0000	0000	0000	0000	3.60+01 3 2018	0000	0000	3.60+01 3	0000	1.73-01 2 2065	0000	0000	0000	2[illegible]00	0.00-01 2 2000	0.00+00 2 0997	39
																40
0000 0000	0000	0000	0000	4.00+01 3 2039	0000	0000	4.00+01 3	0000	0000	0000	0000	0000	2000	0.00-01 2 2000	0.00+00 2 0997	41
																42
																43
																44
																45
																46
																47
																48
																49
																50

TABLE 17. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED DOMESTIC OFF-SHORE REGION OF OIL SUPPLY

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BASED ON (2013,59), DOMESTIC OFFSHORE OIL HAS AN AVERAGE SULFUR CONTENT OF 0.61P. USING THE NATIONAL AVERAGE OF 0.79P (FROM FOOTNOTE 2000) AS A STANDARD, THE OFFSHORE PRODUCED OIL CONTAINS 24.7P LESS SULFUR. FUEL OIL FROM THIS CRUDE WOULD CONTAIN ABOUT 1.16PC S & PETROLEUM COKE WOULD CONTAIN ABOUT 1.39P SULFUR. THE SOX EMISSIONS FROM THE CATALYTIC CRACKING OPERATION, AND FROM THE BURNING OF FUEL OIL, PETROLEUM COKE AND REFINERY GASES WILL DECREASE BY 24.7PC. THESE DECREASES ARE

CAT. CRACKER SOX	3.29E+00	TONS/YR
FUEL OIL COMBUSTION	2.05E+00	
REFINERY GAS COMBUSTION	5.01E+01	
PETROLEUM COKE COMBUSTION	3.85E+00	

2203

SOX EMISSIONS WILL DECREASE BY 24.7P BELOW THOSE FROM FOOTNOTE 2007 (SEE FOOTNOTE 2202). THIS DECREASE AMOUNTS TO 6.50E+00 TONS/YR.

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	CONTROLLED FUEL	CONTROLLED REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	OIL	DOMESTIC OFF-SHORE	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)													
					DISSOLVED SOLIDS											
Row	Symbol	ACTIVITY PROCESS	ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12} BTU)	PARTICULATES	$HC_{[illegible]}$
1	CRTRC	EXTRACTION														
2	OFFSH	OFFSHORE PRODUCTION	0000	0000	0000	0000	0000	0000	0000	1.20+00 3 0036	1.20+00 3	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 [illegible]
3	TRNSP	CRUDE OIL TRANSPORT														
4	PIPEL	PIPELINE	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 0003	0.00+00 3	0000	0000	0000	1.72+01 3 2031	4.89+00 3 [illegible]
5	BARGE	BARGES	0000	0000	0000	0000	0000	0000	0000	7.65+00 3 2027	7.65+00 3	0000	0000	0000	3.07+00 3 2028	7.17+00 3 [illegible]
6	TNKTR	TANK TRUCKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.50+01 3 2029	1.67+01 3 [illegible]
7	TNKCR	TANK CARS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.23+00 3 2030	3.04+00 3 [illegible]
8	PROCS	PROCESSING														
9	NAVRF	NATIONAL AVERAGE REFINERY	0000	0000	0000	0000	3.02+01 2 2100	3.40+01 2 2100	0.00+01 2 2100	3.50+01 2 2100	3.50+01 3	6.06+01 3 2100	6.54+00 3 2100	0.00+00 2 2100	2.73+00 3 2101	1.07+01 3 [illegible]
10	CRDTK	CRUDE OIL STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 [illegible]
11	DSALT	ELECTROSTATIC DESALTING	0000	0000	0000	0000	1.03+01 3 2005	2.23+01 3 2005	0000	1.00+00 3 2005	2.34+01 4	2.67+01 3 2005	2.85+00 3 2005	0.00+00 2 0007	2005	
12	DSTIL	ATMOS. & VAC. DISTILLATION	0000	0000	0000	0000	4.90+02 3 2006	5.12+00 3 2006	0000	1.00+00 3 2006	4.72+00 4	1.78+02 3 2006	4.65+01 3 2006	1.50+10 3 2006	2.07+01 3 2006	2.30+00 3 [illegible]
13	CATCR	CATALYTIC CRACKING	0000	0000	0000	0000	6.00+00 3 2007	7.02+00 3 2007	0000	6.50+00 3 2007	1.72+01 4	1.32+00 3 2007	1.50+00 3 2007	1.74+10 3 2007	3.50+00 3 2107	9.07+00 3 [illegible]
14	CATRF	CATALYTIC REFORMING	0000	0000	0000	0000	9.50+02 3 2008	1.10+01 3 2008	0.00+00 3 0007	4.02+00 3 2008	6.01+00 3	0.00+00 3 0007	3.00+00 3 2008	5.03+01 3 2008	3.32+01 3 2008	3.62+00 3 [illegible]
15	DSTHT	DISTILLATE HYDROTREATING	0000	0000	0000	0000	2.72+00 3 2009	3.01+00 3 2009	0.00+01 3 0007	1.03+04 3 2009	3.01+00 3	0.00+01 3 2009	4.30+00 3 2009	5.37+09 3 2009	1.46+01 3 2009	1.67+01 3 [illegible]
16	COKRG	DELAYED COKING	0000	0000	0000	0000	0000	2.30+00 3 2010	0000	4.93+01 3 2010	2.88+00 3	0000	2.54+00 3 2010	1.72+10 3 2010	5.20+01 3 2010	3.97+00 3 [illegible]
17	DSTRC	DISTILLATE hr/DNCRACKING	0000	0000	0000	0000	1.72+01 3 2011	1.72+01 3 2011	0000	0000	1.72+01 3	1.72+01 3 2011	3.87+00 3 2011	1.63+10 3 2011	2.72+01 3 2011	1.13+00 3 [illegible]
18	ISOMR	ISOMERIZATION	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.20+09 3 2012	1.95+01 3 2012	1.15+01 3 [illegible]
19	ALKYL	ALKYLATION	0000	0000	0000	0000	2.37+00 3 2013	3.56+01 3 2013	0000	3.19+02 3 2013	3.56+01 4	3.19+00 3 2013	1.19+01 3 2013	1.04+11 3 2013	8.25+01 3 2013	9.50+00 3 [illegible]
20	AROMA	AROMATICS EXTRACTION	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.16+10 3 2014	0000	
21	FURFR	FURFURAL REFINING	0000	0000	0000	0000	0000	0000	0000	2.40+01 3 2015	2.40+01 3	0000	0000	5.44+10 3 2015	5.42+01 3 2015	6.23+00 3 [illegible]
22	SLOWX	SOLVENT DEWAXING	0000	0000	0000	0000	0000	0000	0000	1.24+01 3 2016	1.24+01 3	2.00+01 3 2016	0000	7.00+10 3 2016	5.50+01 3 2016	8.32+00 3 [illegible]
23	SGTRT	SOUR GAS TREATING	0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2018	1.25+00 3	6.23+00 3 2018	0000	6.63+00 3 2018	0.00+00 3 2018	9.21+00 3 [illegible]
24	GASTR	GASOLINE TREATING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 [illegible]
25	LUBRT	LUBE OIL HYDROTREATING	0000	0000	0000	0000	2.60+00 3 2020	2.60+00 3 2020	0.00+00 3 0007	8.25+04 3 2020	2.60+00 3	8.25+01 3 2020	4.13+00 3 2020	2.78+10 3 2020	3.62+01 3 2020	4.16+00 3 [illegible]
26	GREAS	GREASE MANUFACTURE	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
27	WXDEW	WAX DEWOLING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.54+01 3 2022	7.53+00 3 [illegible]
28	PROPA	PROPANE DEASPHALTING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.97+10 3 2017	1.61+00 3 2017	1.16+01 3 [illegible]
29	HMFU	HYDROGEN MANUFACTURING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.47+11 3 2023	4.45+00 3 2023	5.67+01 [illegible]
30	RFSTO	REFINERY PRODUCT STORAGE	0000	0000	0000	0000	0000	0000	0000	0000	0000	9.15+02 3 2027	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 [illegible]
31	DSTRB	PRODUCT DISTRIBUTION														
32	PIPEL	PIPELINE	0000	0000	0000	0000	0000	0000	0000	6.22+02 3 2003	6.22+02 3	0000	0000	0000	1.72+01 3 2031	4.89+00 3 [illegible]
33	TANKR	TANKERS	0000	0000	0000	0000	0000	0000	0000	9.07+00 2 2127	9.07+00 3	0000	0000	0000	3.75+02 3 2032	3.37+01 3 [illegible]
34	SUPER	SUPERTANKERS	0000	0000	0000	0000	0000	0000	0000	9.07+00 2 2127	9.07+00 3	0000	0000	0000	3.75+02 3 2032	3.37+01 3 [illegible]
35	BARGE	BARGES	0000	0000	0000	0000	0000	0000	0000	7.65+00 2 2024	7.65+00 3	0000	0000	0000	3.02+00 3 2033	2.17+00 3 [illegible]
36	TNKTR	TANK TRUCKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.50+01 3 2029	1.67+01 3 [illegible]
37	TNKCR	TANK CARS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.23+00 3 2030	3.04+00 3 [illegible]
38	PTERM	PRODUCT TERMINALS														
39	TNKST	STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
40	MRKT	MARKETING														
41	GAST	AUTO GASOLINE TANK FILL	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
42																
43																
44																
45																
46																
47																
48																
49																
50																

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
		AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
	THERMAL BTU/10^{12} BTU	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/10^{12} BTU	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	ROW
																	1
	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0000	3.16-01 3 2001	5.70-06 4 2033	2.61-04 4 2033	5.85-01 4 2033	2000	3.00-01 3 2000	0000	2
																	3
	0000	1.73-01 3 2031	4.00+00 3 2031	5.57-01 3 2031	4.90-01 3 2031	2.00+00 3 2031	7.04-02 3 2031	8.07+00 3	0000	6.38+01 2 2002	3.36-05 4 2034	2.79-03 4 2034	6.46-02 4 2034	2007	1.00+00 3 2001	3.30+00 3 2001	4
	0000	3.02+00 3 2028	2.17+00 3 2028	2.31+00 3 2028	1.40+00 3 2028	1.09+00 3 2028	1.09-01 3 2028	1.00+01 3	0000	1.01-01 3 2071	0000	0000	0000	2000	1.00+00 2 2003	2.52+10 3 2003	5
	0000	0.56-01 3 2030	1.07+01 3 2029	1.37+00 3 2029	1.67+00 3 2029	1.14+01 3 2029	3.06-01 3 2029	3.63+01 3	0000	3.52+02 2 2007	0000	0000	0000	2000	0000	1.38+10 3 2030	6
	0000	1.20+00 1 2030	3.04+00 3 2030	3.33+00 3 2030	2.58+00 3 2030	2.10+00 3 2030	5.00-01 3 2030	1.52+01 3	0000	1.09+01 3 2010	0000	0000	0000	2000	0000	1.42+10 3 2030	7
																	8
	0.00+00 2 2103	2.73+00 3 2101	1.07+01 3 2101	1.78+01 3 2102	3.30+01 3 2101	1.00-01 3 2101	2.71+00 3 2101	4.78+01 3	4.37+01 4 2106	1.03+01 4 2103	4.33-04 3 2041	1.03-02 3 2041	2.05-00 3 2041	2001	0.38-01 3 2003	5.04+10 3 2106	9
	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	5.40+00 3 2123	0.00+00 2 0007	0.00+00 2 0007	5.40+00 3	0000	1.01-01 3 2071	0000	0000	0000	2002	1.00+00 2 2123	0.00+00 2 0007	10
	0.00+00 2 0007	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	1.09+07 2 2005	11
	1.50+10 3 2006	2.07-01 3 2006	2.36+00 3 2006	6.21-02 3 2006	2.90+00 3 2106	4.14-03 3 2006	1.04-01 3 2006	5.60+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	2.31+10 2 2006	12
	1.76+10 3 2007	1.00+00 3 2107	0.07+00 3 2107	2.33+01 3 2103	3.00+00 3 2107	2.70-01 3 2107	0.57+00 3 2107	4.16+01 3	4.17+00 3 2107	0.00	0000	0000	0000	2001	1.00+00 2 2079	3.01+10 2 2107	13
	5.93+00 3 2004	1.12-01 3 2008	3.02+00 3 2008	9.07-03 3 2008	2.00+00 3 2108	6.03-02 3 2008	1.18-01 3 2008	7.30+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	6.38+10 2 2008	14
	5.37+00 3 2009	1.46-02 3 2009	1.67-01 3 2009	4.37-04 3 2009	2.39+00 3 2109	2.91-04 3 2009	7.27-03 3 2009	5.47+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	1.30+00 2 2009	15
	1.72+10 3 2010	5.20-01 3 2010	5.07+00 3 2010	1.50-02 3 2010	2.77+00 3 2110	1.04-02 3 2010	2.40-01 3 2010	9.10+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	6.17+10 2 2010	16
	1.43+10 3 2011	1.72-01 3 2011	3.13+00 3 2011	6.10-03 3 2011	2.03+00 3 2111	5.44-03 3 2011	1.30-01 3 2011	6.17+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	4.50+10 2 2011	17
	2.25+00 3 2012	1.95-01 3 2012	1.11+01 3 2012	5.93-03 3 2012	3.07+00 3 2112	1.68-02 3 2012	8.72-02 3 2012	1.08+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	2.52+10 2 2012	18
	1.04+11 3 2013	8.25-01 3 2013	9.50+00 3 2013	2.40-03 3 2013	5.53+00 3 2113	1.05-02 3 2013	6.13-01 3 2013	1.63+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	8.50+10 2 2013	19
	6.10+10 3 2014	0000	0000	0000	2.60+00 3 2114	0000	0000	2.60+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	0000	20
	3.60+10 3 2015	5.42-01 3 2015	6.23+00 3 2015	1.02-02 3 2015	2.00+00 3 2115	1.00-02 3 2015	2.71-01 3 2015	1.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	5.75+10 2 2015	21
	7.00+10 3 2016	3.30-01 3 2016	6.32+00 3 2016	1.65-02 3 2016	3.19+00 3 2116	1.10-02 3 2016	2.76-01 3 2016	1.04+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	7.00+10 2 2016	22
	4.61+00 3 2016	8.00-02 3 2016	9.20-02 3 2016	2.60-04 3 2016	4.04+00 3 2116	1.00-04 3 2016	6.00-03 3 2016	4.10+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	1.07+00 3 2016	23
	0.00+00 3 2016	0.00+00 3 2016	0.00+00 3 2016	0.00+00 3 2016	2.47+00 3 2116	0.00+00 3 2016	0.00+00 3 2016	2.47+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	0000	24
	2.76+01 3 2020	3.62-01 3 2020	4.18+00 3 2020	1.13-02 3 2020	2.71+00 3 2120	7.23-03 3 2020	1.01-01 3 2020	7.45+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	4.13+10 2 2020	25
	0000	0000	0000	0000	3.03+00 3 2121	0000	0000	3.03+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	0000	26
	3.77+10 3 2022	4.14-01 3 2022	7.32+00 3 2022	1.07-02 3 2022	3.20+00 3 2122	1.11-02 3 2022	3.27-01 3 2022	1.10+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	8.41+10 2 2022	27
	6.07+10 3 2017	1.01+00 3 2017	1.10+01 3 2017	3.03-02 3 2017	3.40+00 3 2117	2.02-02 3 2017	4.04-01 3 2017	1.08+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	1.00+11 2 2017	28
	2.47+11 3 2023	4.45+00 3 2023	5.07+01 3 2023	1.40-01 3 2023	9.50+00 3 2023	8.80-02 3 2023	1.45+00 3 2023	[illegible] 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2079	1.03+12 2 2079	29
	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3 2130	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3	0000	1.00-01 3 2071	0000	0000	0000	2001	1.00+00 2 2130	0.00+00 2 0007	30
																	31
	0000	1.72-01 3 2032	4.00+00 3 2032	2.57-01 3 2032	4.00-01 3 2032	2.00+00 3 2032	7.04-02 3 2032	8.07+00 3	0000	3.79-01 3 2000	6.30-03 3 2042	6.30-03 3 2042	1.00-01 3 2042	2007	1.00+00 2 2001	3.00+00 2 2001	32
	0000	3.75-02 3 2032	3.37-01 3 2032	9.15-01 3 2032	1.00-02 3 2032	8.14-03 3 2032	5.30-03 3 2032	9.18-01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 2 2127	4.07+10 2 2002	33
	0000	2.75-02 3 2032	3.37-01 3 2032	9.15-01 3 2032	1.00-02 3 2032	6.16-03 3 2032	3.30-03 3 2032	6.18-01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 2 2127	4.07+10 2 2002	34
	0000	3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032	1.40+00 3 2032	1.00+00 3 2032	1.09-01 3 2032	1.00+01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 2 2002	2.07+10 2 2002	35
	0000	0.59-01 3 2032	1.07+01 3 2032	1.37+00 3 2032	1.67+00 3 2032	1.14+01 3 2032	3.06-01 3 2032	3.63+01 3	0000	3.52+02 2 2000	0000	0000	0000	2000	0000	1.41+10 2 2030	36
	0000	1.20+00 3 2032	3.04+00 3 2032	3.33+00 3 2032	2.58+10 3 2032	2.10+00 3 2032	5.00-01 3 2032	1.52+01 3	0000	1.00-01 3 2000	0000	0000	0000	2000	0000	1.45+10 2 2030	37
																	38
	0000	0000	0000	0000	1.00+00 2 2130	0000	0000	1.00+00 2 2130	0000	1.73-01 2 0000	0000	0000	0000	2000	1.00+00 2 2127	0.00+00 2 0007	39
																	40
	0000	0000	0000	0000	0.00+00 2 2130	0000	0000	0.00+00 2 2130	0000	0000	0000	0000	0000	2000	1.00+00 2 2130	0.00+00 2 0007	41
																	42
																	43
																	44
																	45
																	46
																	47
																	48
																	49
																	50

TABLE 18. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED DOMESTIC OFF-SHORE REGION OF OIL SUPPLY

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2302

BASED ON (2018,59), DOMESTIC OFFSHORE OIL HAS AN AVERAGE SULFUR CONTENT OF 0.61 PC. BASED ON 3.2 PC OF THE S IN THE CRUDE BEING DISCHARGED FROM THE CAT CRACKER REGENERATOR (FOOTNOTE 2107), THE CAT CRACKING SO2 EMISSION FOR A 178000 BBL/YR REFINERY (1.0E12 BTU/YR) IS 10.25 TON SO2/YR. BASED ON 48.8 PC OF THE S IN THE CRUDE AS H2S IN THE REFINERY PROCESS GAS (FOOTNOTE 2066), WITH .3 TON S EMITTED IN THE COMBUSTION OF THIS PROCESS GAS (FOOTNOTE 2101), AND WITH A 99.9 PC RECOVERY OF THE S IN THE PROCESS GAS SENT TO THE CLAUS PLANT AND TAIL-GAS UNIT (FOOTNOTE 2101), .16 TON OF SO2 IS DISCHARGED YEARLY FROM THE CLAUS UNIT. FUEL COMBUSTION SO2 EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2101 AND ARE LIMITED BY REGULATIONS.

2303

LAND REQUIREMENTS FOR PRINCIPAL SULFUR RECOVERY PROCESS EQUIPMENT, STORAGE, INCINERATOR AND STACK,CHANGES TO 2.91E-04 ACRES (FROM FOOTNOTE 2105) AND RESULTS IN A TOTAL INCREMENTAL LAND REQUIREMENT FOR CONTROLS ON A 1.0E12 BTU/YR REFINERY OF 2.05E-02 ACRES. THIS IS PROVIDED FOR IN THE REFINERY FIGURE GIVEN IN FOOTNOTE 2040.

2304

BASED ON FOOTNOTE 2125 AND 0.61 PC S IN THE CRUDE, THE ENERGY REQUIREMENT FOR OPERATION OF THE CLAUS PLANT AND TAIL-GAS UNIT IS 1.71E08 BTU/YR. FROM FOOTNOTE 2125 THE ANCILLARY ENERGY REQUIREMENT FOR A 1.0E12 BTU/YR REFINERY CHANGES TO 5.04E10 BTU/YR.

2305

FROM FOOTNOTE 2302,THE CAT CRACKER SO2 EMISSION FOR A 1.0E12 BTU/YR REFINERY IS 10.25 TON SO2/YR. FOR 1.0E12 BTU/YR INPUT TO THE CAT CRACKER MULTIPLY THIS BY 1.98 (FOOTNOTE 2107).

		UNCONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		FUEL	REGION														
		OIL	IMPORTED CANADIAN CRUDE	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)													
ROW	MNE-MON	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS				SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12}BTU	PARTIC-ULATES	NO_x
						PO_4	NO_3	OTHER	TOTAL (DS)								
1	TRNSP	CRUDE OIL TRANSPORT															
2	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	0.00-02 5 2003	0.00-02 5	0000	0000	0000	1.72-01 3 2021	4.09+00 3 [illegible]
3	PROCS	PROCESSING															
4	NAVRF	NATIONAL AVERAGE REFINERY		0000	0000	0000	0000	1.45+00 2 2006	1.58+01 5 2006	3.22+01 2 2006	0.00+00 2 2006	6.66+01 1	6.02+00 2 2006	1.02+01 2 2006	7.00+10 4 2006	9.10+00 3 2006	2.28+01 3 [illegible]
5	CRDTK	CRUDE OIL STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00-02 3 2036		0000	0.00+00 2 0007	0.00+00 2 [illegible]
6	DSALT	ELECTROSTATIC DESALTING		0000	0000	0000	0000	1.02-01 3 2005	2.23+01 3 2005	0000	1.07+00 3 2005	2.34+01 4	2.67-01 3 2005	2.85+00 3 2005	0.00+00 2 0007	2005	[illegible]
7	DSTIL	ATMOS. & VAC. DISTILLATION		0000	0000	0000	0000	8.90-02 3 2006	3.12-00 3 2006	0000	1.60+00 3 2006	4.72+00 4	1.78-02 3 2006	4.45-01 3 2006	1.30+10 3 2006	2.07-01 3 2006	2.18+00 3 [illegible]
8	CATCR	CATALYTIC CRACKING		0000	0000	0000	0000	6.68+00 3 2007	7.92+00 3 2007	0000	9.24+00 3 2007	1.72+01 4	1.32+00 3 2007	1.58+00 3 2007	1.14+10 3 2007	5.68+00 3 2007	6.07+00 3 [illegible]
9	CATRF	CATALYTIC REFORMING		0000	0000	0000	0000	8.50-02 3 2008	1.19+01 3 2008	0.00+00 3 0007	4.82+00 3 2008	6.01+00 3	0.00+00 3 0007	3.80+00 3 2008	5.81+09 3 2008	3.12-01 3 2008	3.82+00 3 [illegible]
10	DSTHT	DISTILLATE HYDROTREATING		0000	0000	0000	0000	2.73+00 3 2009	3.01+00 3 2009	0.00+00 3 0007	6.60-04 3 2009	3.01+00 3	6.60-01 3 2009	4.30+00 3 2009	5.37+09 3 2009	1.46-02 3 2009	1.67-01 3 [illegible]
11	COKG	DELAYED COKING		0000	0000	0000	0000	0000	2.39+00 3 2010	0000	4.83-01 3 2010	2.88+00 3	0000	2.54+00 3 2010	1.72+10 3 2010	5.26-01 3 2010	5.67+00 3 [illegible]
12	DSTHC	DISTILLATE HYDROCRACKING		0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 5	1.72-01 3 2011	3.67+00 3 2011	1.43+10 3 2011	2.72-01 3 2011	3.13+00 3 [illegible]
13	ISOMR	ISOMERIZATION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+09 3 2012	1.85-01 3 2012	2.13+01 3 [illegible]
14	ALKYL	ALKYLATION		0000	0000	0000	0000	2.37+00 3 2013	3.56+01 3 2013	0000	1.10-02 3 2013	5.58+01 4	1.10+00 3 2013	1.10-01 3 2013	1.94+11 3 2013	4.22-01 3 2013	9.10+00 3 [illegible]
15	AROMX	AROMATICS EXTRACTION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.16+10 3 2014	0000	[illegible]
16	FURFR	FURFURAL REFINING		0000	0000	0000	0000	0000	0000	0000	2.48-01 3 2015	2.48-01 5	0000	0000	3.46-10 3 2015	3.42-01 3 2015	4.23+00 3 [illegible]
17	SLDWX	SOLVENT DEWAXING		0000	0000	0000	0000	0000	0000	0000	1.24-01 3 2016	1.24-01 5	2.06-01 3 2016	0000	7.65+10 3 2016	5.50-01 3 2016	8.32+00 3 [illegible]
18	SGTRT	SOUR GAS TREATING		0000	0000	0000	0000	0000	0000	0000	1.25+00 2 2018	1.25+00 5	8.23+00 3 2018	0000	8.43+00 3 2018	[illegible]	[illegible]
19	GASTR	GASOLINE TREATING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	9.10+00 3 2019	5.00+00 3 2019	0.00+00 3 [illegible]
20	LUBRC	LUBE OIL HYDROTREATING		0000	0000	0000	0001	2.56+00 3 2020	2.89+00 3 2020	0.00+00 3 0007	8.25-04 3 2020	2.89+00 3	8.25-01 3 2020	4.13+00 3 2020	2.79+10 3 2020	3.62-01 3 2020	4.15+00 3 [illegible]
21	GREAS	GREASE MANUFACTURE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible]
22	WXDEW	WAX DEWILING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.34-01 3 2022	1.52+00 3 [illegible]
23	PROPA	PROPANE DEASPHALTING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.97+10 3 2017	1.03+00 3 2017	1.16+01 3 [illegible]
24	HYDRO	HYDROGEN MANUFACTURING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.47+11 3 2023	4.45+00 3 2023	5.57+01 3 [illegible]
25	RFS TG	REFINERY PRODUCT STORAGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	8.15-02 3 2007	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 3 [illegible]
26	DSTR	PRODUCT DISTRIBUTION															
27	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	6.22-02 5 2062	6.22-02 5	0000	0000	0000	1.72-01 3 2032	4.09+00 3 [illegible]
28	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	3.08+01 2 2063	3.08+01 2	0000	0000	0000	3.75-02 3 2032	3.37-01 3 [illegible]
29	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	3.08+01 2 2063	3.08+01 2	0000	0000	0000	3.75-02 3 2032	3.37-01 3 [illegible]
30	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.68+00 2 2064	7.68+00 2	0000	0000	0000	3.02+00 3 2032	3.17+00 3 [illegible]
31	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.38-01 3 2032	1.67+01 3 [illegible]
32	TNKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032	1.64+00 3 [illegible]
33	PTERM	PRODUCT TERMINALS															
34	TNKST	STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible]
35	MRKT	MARKETING															
36	GAST	AUTO GASOLINE TANK FILL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible]
37																	
38																	
39																	
40																	
41																	
42																	
43																	
44																	
45																	
46																	

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
		AIR POLLUTANTS (TONS/10^{12} BTU)						SOLIDS (TONS/10^{12}BTU)	LAND (ACRE-YR/10^{12} BTU)	OCCUPATIONAL HEALTH			POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12}BTU)	ROW
THERMAL (BTU/10^{12}BTU)		PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL			DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12}BTU			
																1
0000	0000	1.72+01 3 2031	1.09+00 3 2031	3.57-01 3 2031	4.00-01 3 2031	2.00+00 3 2031	1.96+02 3 2031	0.97+00 3	0000	0.36+01 3 2000	3.30-05 4 2034	2.70-03 4 2034	8.46-05 4 2034	2007	1.00+00 2 2041	2.00+00 2 2041	2
																3
2006	7.00+10 4 2006	0.11+00 3 2006	2.20+01 3 2006	1.70+02 4 2006	2.32+02 3 2006	6.11+02 3 2006	1.73+03 3 2006	1.08+03 4	2.47+08 4 2006	1.03+01 4 2000	4.35-05 3 2041	3.81-02 3 2041	3.01-06 3 2041	2001	9.32-01 3 2000	5.00+10 3 2006	4
0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	6.72+01 3 2006	0.00+00 2 0007	0.00+00 2 0007	0.72+01 3	0000	1.01-01 3 2071	0000	0000	0000	2002	0.00-01 2 2000	0.00+00 2 0007	5
2005	0.00+00 2 0007	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.00+07 2 2006	6
2006	1.50+10 3 2006	2.07-01 3 2006	2.42-01 3 2006	6.21-02 3 2006	2.02-01 3 2006	4.14-03 3 2006	1.06-01 3 2006	3.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	2.21+10 2 2006	7
2007	1.76+10 3 2007	3.68+00 3 2007	1.07+00 3 2007	1.07+01 4 2006	2.72+01 3 2007	2.21+01 3 2007	8.31+00 3 2007	1.20+03 4	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	3.35+10 2 2007	8
2008	3.00+00 3 2008	3.32-01 3 2008	3.57+00 3 2008	8.97-03 3 2008	1.48+00 3 2008	6.03-02 3 2008	1.36-01 3 2008	1.91+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.35+10 2 2008	9
2009	5.37+00 3 2009	1.40-02 3 2009	1.67-01 3 2009	4.37-04 3 2009	1.89+01 3 2009	2.01-04 3 2009	7.27-02 3 2009	1.40+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.00+00 2 2009	10
2010	1.72+10 3 2010	5.20-01 3 2010	3.97+00 3 2010	1.30-02 3 2010	5.00+01 3 2010	1.04-02 3 2010	2.00-01 3 2010	1.74+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	8.17+10 2 2010	11
2011	1.62+10 3 2011	2.72-01 3 2011	3.13+00 3 2011	6.10-03 3 2011	2.30+01 3 2011	5.44-03 3 2011	1.36-01 3 2011	1.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.59+10 2 2011	12
2012	2.30+00 3 2012	1.95-01 3 2012	1.13+01 3 2012	7.43-03 3 2012	1.31+01 3 2012	3.00-02 3 2012	6.72-02 3 2012	2.50+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	2.33+10 2 2012	13
2013	1.34+11 3 2013	0.23-01 3 2013	3.50+00 3 2013	2.66-02 3 2013	5.11+01 3 2013	1.60-02 3 2013	4.12-01 3 2013	8.10+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	8.90+10 2 2013	14
2014	4.10+10 3 2014	0000	0000	0000	1.01+01 3 2014	0000	0000	1.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	15
2015	3.66+10 3 2015	1.02-01 3 2015	1.23+00 3 2015	1.02-02 3 2015	7.21+00 3 2015	1.00-02 3 2015	1.71-01 3 2015	2.12-01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	3.75+10 2 2015	16
2016	7.00+10 3 2016	3.50-01 3 2016	5.32+00 3 2016	1.81-02 3 2016	1.00+01 3 2016	1.10-02 3 2016	2.74-01 3 2016	2.62+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	7.00+10 2 2016	17
2017	6.45+00 3 2016	0.00-01 3 2016	5.25-00 3 2016	2.00-04 3 2016	4.00+01 3 2016	1.00-04 3 2016	4.00-03 3 2016	4.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.07+00 2 2016	18
2018	0.00+00 3 2018	0.00+00 3 2018	0.00+00 3 2018	0.00+00 3 2018	1.21+01 3 2018	0.00+00 3 2018	0.00+00 3 2018	1.21+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	19
2020	2.00+10 3 2020	3.07-01 3 2020	4.10+00 3 2020	1.12-02 3 2020	1.30+01 3 2020	7.23-03 3 2020	1.81-01 3 2020	1.65+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	4.12+10 2 2020	20
0000	0000	0000	0000	0000	9.94+00 4 2021	0000	0000	9.94+00 3 2003	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	0000	21
2022	3.77+10 3 2022	6.34-01 3 2022	1.32+00 3 2022	1.97-02 3 2022	1.10+01 3 2022	1.21-02 3 2022	3.27-01 3 2022	2.66+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	8.41+10 2 2022	22
2017	4.07+10 3 2017	1.91+00 3 2017	1.10+01 3 2017	1.12-02 3 2017	1.11+01 3 2017	2.02-02 3 2017	3.04-01 3 2017	3.63+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2070	1.08+11 2 2017	23
2023	0.47+11 3 2023	6.45-00 3 2023	3.07-01 3 2023	1.40-01 3 2023	0.00-00 3 2023	0.00-00 3 2023	1.40-00 3 2023	7.50-01 3	0000	0000	0000	0000	0000	2001	1.03-012 2070	0.00+00 2 2070	24
0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	9.93+01 3 2017	4.00-00 2 2007	0.00+00 2 0007	9.93+01 3	0000	1.04-01 3 2071	0000	0000	0000	2002	1.00-01 3 2000	0.00+00 2 0007	25
																26
0000	0000	1.72-01 3 2032	1.09+00 3 2032	3.57-01 3 2032	4.00-01 3 2032	2.00+00 3 2032	1.96-02 3 2032	0.97+00 3	0000	3.79+01 2 2000	0.00-01 3 2042	4.20-03 3 2042	1.00-01 3 2042	2007	1.00+00 7 2001	3.00+10 2 2041	27
0000	0000	1.75-02 3 2032	1.37-01 3 2032	5.15-01 3 2032	1.00-02 3 2032	5.14-03 3 2032	1.35-01 3 2032	0.10-01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	0.00-01 3 2002	0.07+10 2 2042	28
0000	0000	1.75-02 3 2032	1.37-01 3 2032	5.15-01 3 2032	1.00-02 3 2032	5.14-03 3 2032	1.35-01 3 2032	0.10-01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	0.00-01 3 2002	4.07+10 2 2042	29
0000	0000	3.02+00 3 2032	2.17+00 3 2032	7.31+00 3 2032	1.00+00 3 2032	1.00+00 3 2032	1.00-01 3 2032	1.00+01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 7 2002	2.07+10 2 2042	30
0000	0000	6.30-01 3 2032	1.47+01 3 2032	1.27+00 3 2032	1.07+00 3 2032	1.14+01 3 2032	3.00-01 3 2032	2.63+01 3	0000	3.03+02 3 2000	0000	0000	0000	2000	0000	1.41+10 2 2030	31
0000	0000	1.20+00 3 2032	3.00+00 3 2032	3.13+00 3 2032	3.50+00 3 2032	3.50+00 3 2032	5.00-01 3 2032	1.12-01 3	0000	1.00+01 3 2000	0000	0000	0000	2000	0000	1.40+10 2 2030	32
																33
0000	0000	0000	0000	0000	3.00+01 3 2030	0000	0000	1.00+01 3	0000	1.73-01 2 2000	0000	0000	0000	2000	0.00-01 2 2000	0.00+00 2 0007	34
																35
0000	0000	0000	0000	0000	4.00+01 3 2030	0000	0000	4.00+01 3	0000	0000	0000	0000	0000	2000	0.00-01 2 2000	0.00+00 2 0007	36
																37
																38
																39
																40
																41
																42
																43
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																45
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TABLE 19. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED IMPORTED CANADIAN CRUDE REGION OF OIL SUPPLY

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2204

BASED ON(2019,1/13), CANADIAN CRUDE OIL HAS AN AVERAGE SULFUR CONTENT OF 0.59P. USING THE NATIONAL AVERAGE OF 0.79P (FROM FOOTNOTE 2000) AS A STANDARD, THE CANADIAN OIL CONTAINS 25.3P LESS SULFUR. FUEL OIL FROM THIS CRUDE WOULD CONTAIN 1.12P S & PETROLEUM COKE WOULD CONTAIN 1.34P S.THE SOX EMISSIONS FROM THE CATALYTIC CRACKING OPERATION, AND FROM THE BURNING OF FUEL OIL, PETROLEUM COKE AND REFINERY GASES WILL DECREASE BY 25.3P. THESE DECREASES ARE

CAT. CRACKER SOX 3.37E+0[illegible] TONS/YR
FUEL OIL COMBUSTION 2.10E+00
REFINERY GAS COMBUSTION 5.13E+01
PETROLEUM COKE COMBUSTION 3.94E+00

2205

SOX EMISSIONS WILL DECREASE BY 25.3P BELOW THOSE FROM FOOTNOTE 2007(SEE FOOTNOTE 2204). THIS DECREASE AMOUNTS TO 6.65E+00 TONS/YR.

		CONTROLLED FUEL: OIL	CONTROLLED REGION: IMPORTED CANADIAN CRUDE	1	2	3	4	5	6	7	8	9	10	11	12	13
				WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 1)												
						DISSOLVED SOLIDS										
ROW	MNE-MONIC	ACTIVITY PROCESS		ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12} BTU	PARTIC-ULATES
1	TRANS	CRUDE OIL TRANSPORT														
2	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	0.00-02 5 2003	0.00-02 5	0000	0000	0000	1.72-01 3 2031
3	PROCS	PROCESSING														
4	NAVRE	NATIONAL AVERAGE REFINERY		0000	0000	0000	0000	3.00-01 5 2100	3.00+01 5 2100	0.00-01 5 2100	3.00-01 5 2100	3.00-01 5	0.00-01 3 2100	0.00+00 3 2100	0.00+00 3 2100	2.72+00 3 2101
5	CRDTK	CRUDE OIL STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00-02 3 2036	0000	0.00+00 3 0007	0.00+00 3 0007
6	DSALT	ELECTROSTATIC DESALTING		0000	0000	0000	0000	1.03+01 3 2005	2.23+01 3 2005	0000	1.07+00 3 2005	2.34+01 4	2.07-01 3 2005	2.05+00 3 2005	0.00+00 3 0007	2005
7	DSTIL	ATMOS. & VAC. DISTILLATION		0000	0000	0000	0000	3.95-02 3 2006	3.12+00 3 2006	0000	1.50+00 3 2006	4.72+05 4	1.75-02 3 2006	4.65-01 3 2006	1.50+10 3 2006	2.07-01 3 2006
8	CATCR	CATALYTIC CRACKING		0000	0000	0000	0000	0.00+00 3 2007	7.02+00 3 2007	0000	0.26+00 3 2007	1.72+01 4	1.32+00 3 2007	1.58+00 3 2007	1.76+10 3 2007	3.50+00 3 2107
9	CATRF	CATALYTIC REFORMING		0000	0000	0000	0000	2.50-02 3 2008	1.10+01 3 2008	0.00+00 3 0007	0.02+00 3 2008	0.01+00 3	0.00+00 3 0007	3.80+00 3 2008	5.03+00 3 2008	3.72-01 3 2008
10	DSTRF	DISTILLATE HYDROTREATING		0000	0000	0000	0000	2.72+00 3 2009	3.01+00 3 2009	0.00+00 3 0007	0.00-04 3 2009	3.01+00 3	0.00-01 3 2009	4.36+00 3 2009	5.37+00 3 2009	1.46-02 3 2009
11	COKER	DELAYED COKING		0000	0000	0000	0000	0000	2.39+00 3 2010	0000	4.83-11 3 2010	2.88+00 3	0000	2.56+00 3 2010	1.72+10 3 2010	5.20-01 3 2010
12	DSTHC	DISTILLATE HYDROCRACKING		0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 5	1.72-01 3 2011	3.07+00 3 2011	1.63+10 3 2011	[illegible] 3 2011
13	ISOMR	ISOMERIZATION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+00 3 2012	[illegible] 3 2012
14	ALKYL	ALKYLATION		0000	0000	0000	0000	2.37+00 3 2013	3.56+01 3 2013	0000	1.19-02 3 2013	3.56+01 4	1.19+00 3 2013	1.19+01 3 2013	1.04+11 3 2013	6.25-01 3 2013
15	AROM	AROMATICS EXTRACTION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.18+10 3 2014	0000
16	FURFR	FURFURAL REFINING		0000	0000	0000	0000	0000	0000	0000	2.40-01 3 2015	2.40-01 5	0000	0000	3.44+10 3 2015	5.42-01 3 2015
17	SLDWX	SOLVENT DEWAXING		0000	0000	0000	0000	0000	0000	0000	1.26-01 3 2016	1.26-01 5	2.00+01 3 2016	0000	7.00+10 3 2016	5.50-01 3 2016
18	SOTRT	SOUR GAS TREATING		0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2018	1.25+00 5	0.23+00 3 2018	0000	0.63+00 3 2018	0.00-03 3 2018
19	GASTR	GASOLINE TREATING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2018	0.00+00 3 2018
20	LUBEC	LUBE OIL HYDROTREATING		0000	0000	0000	0000	2.84+00 3 2020	2.09+00 3 2020	0.00+00 3 0007	0.25-04 3 2020	2.00+00 3	0.25-01 3 2020	6.13+00 3 2020	2.78+10 3 2020	3.02-01 3 2020
21	GRSAF	GREASE MANUFACTURE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
22	WXDCG	WAX DEOILING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.77+10 3 2022	0.56-01 3 2022
23	PROPA	PROPANE DEASPHALTING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.07+10 3 2017	1.01+00 3 2017
24	HDRFY	HYDROGEN MANUFACTURING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	[illegible].47+11 3 2023	[illegible].45+00 3 2023
25	RFSTO	REFINERY PRODUCT STORAGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.10-02 3 2027	0000	0.00+00 3 0007	0.00+00 3 0007
26	DISTR	PRODUCT DISTRIBUTION														
27	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	0.22-02 5 2002	0.22-02 5	0000	0000	0000	1.72-01 3 2032
28	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	0.07+00 3 2127	0.07+00 3	0000	0000	0000	3.75-02 3 2033
29	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	0.07+00 3 2127	0.07+00 3	0000	0000	0000	3.75-02 3 2033
30	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.06+00 3 2004	7.00+00 3	0000	0000	0000	2.02+00 3 2032
31	TNKTK	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.50-01 3 2032
32	TNKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.29+00 3 2032
33	PTERM	PRODUCT TERMINALS														
34	TNKST	STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
35	MRKT	MARKETING														
36	GASFT	AUTO GASOLINE TANK FILL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
37																
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
THERMAL BTU/10^{12} BTU	AIR POLLUTANTS (TONS/10^{12} BTU)							SOLIDS TONS/10^{12} BTU	LAND (ACRE-YR/10^{12} BTU)	OCCUPATIONAL HEALTH			POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	ROW
	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL			DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU				
																1
0000	1.72-01 3 2031	6.00+00 3 2031	3.07-01 3 2031	4.00-01 3 2031	2.90+00 3 2031	7.94-02 3 2031	8.07+00 3	0000	0.30+01 3 2002	3.30-05 4 2034	3.70-03 4 2034	5.46-02 4 2034	2007	1.00+00 3 2001	2.09+09 3 2001	2
																3
0.00+00 2 2100	3.73+00 3 2101	1.07+01 3 2101	1.76+01 3 2101	2.30+01 3 2101	1.00-01 3 2101	3.71+00 3 2101	6.75+01 3	4.27+01 4 2101	1.03+01 4 2107	4.30-05 3 2041	3.02-03 3 2041	2.05+00 3 2041	2004	0.30-01 3 2000	5.04+10 3 2300	4
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 2133	0.00+00 2 0007	0.00+00 2 0007	0.00+00 3	0000	1.01-01 3 2071	0000	0000	0000	2002	1.00+00 3 2133	0.00+00 3 0007	5
0.00+00 2 0007	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	1.00+07 3 2000	6
1.30+10 2 2006	2.07-01 3 2006	2.30+00 3 2006	6.21-03 3 2006	2.00+00 3 2106	4.16-03 3 2006	1.04-01 3 2006	3.09+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	3.33+10 3 2000	7
1.76+10 2 2007	1.00+00 3 2107	0.07+00 3 2107	1.87+01 3 2306	2.00+00 3 2107	2.79-01 3 2107	8.07+00 3 2107	4.10+01 3	6.17+00 3 2107	0000	0000	0000	0000	2001	1.00+00 3 2070	3.33+10 3 2107	8
3.03+00 2 2000	3.32-01 3 2000	3.67+00 3 2000	0.07-03 3 2000	2.00+00 3 2100	6.65-03 3 2000	1.30-01 3 2000	7.00+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	4.35+10 3 2000	9
3.27+00 3 2000	1.40-02 3 2000	1.07-01 3 2000	4.37-04 3 2000	2.30+00 3 2100	3.01-04 3 2000	7.27-03 3 2000	2.07+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	1.30+08 3 2000	10
1.72+10 3 2010	6.20-01 3 2010	5.07+00 3 2010	1.34-02 3 2010	2.77+00 3 2110	1.04-02 3 2010	2.00-01 3 2010	8.10+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0.17+10 3 2010	11
1.52+10 3 2011	2.72-01 3 2011	3.13+00 3 2011	0.10-03 3 2011	2.00+00 3 2111	3.46-03 3 2011	1.36-01 3 2011	6.17+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	6.50+10 3 2011	12
2.03+00 3 2012	1.05-01 3 2012	1.13+01 3 2012	5.03-03 3 2012	2.07+00 3 2112	2.10-03 3 2012	2.72-02 3 2012	1.40+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	2.30+10 3 2012	13
1.04+11 3 2013	0.29-01 3 2013	3.50+00 3 2013	2.08-03 3 2013	2.00+00 3 2113	1.01-03 3 2013	4.12-01 3 2013	4.03+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0.00+10 3 2013	14
0.10+10 3 2014	0000	0000	0000	2.00+00 3 2114	0000	0000	2.00+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0000	15
0.00+10 3 2015	5.02-01 3 2015	0.22+00 3 2015	1.02-03 3 2015	2.00+00 3 2115	1.09-03 3 2015	1.71-01 3 2015	1.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	3.79+10 3 2015	16
7.00+10 3 2016	3.30-01 3 2016	0.51+00 3 2016	1.05-03 3 2016	2.10+00 3 2116	1.10-03 3 2016	2.76-01 3 2016	3.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	7.00+10 3 2016	17
0.03+00 3 2016	0.00-01 3 2016	0.29-03 3 2016	2.00-04 3 2016	4.00+00 3 2116	1.00-04 3 2016	4.00-03 3 2016	4.14+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	1.07+00 3 2016	18
0.00+00 3 2016	0.00+00 3 2016	0.00+00 3 2016	0.00+00 3 2016	2.07+00 3 2116	0.00+00 3 2016	0.00+00 3 2016	2.07+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0000	19
0.70+10 3 2020	3.62-01 3 2020	6.10+00 3 2020	1.12-02 3 2020	2.71+00 3 2120	7.22-03 3 2020	1.01-01 3 2020	7.43+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	4.12+10 3 2020	20
0000	0000	0000	0000	2.03+00 3 2121	0000	0000	2.00+00 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0000	21
3.77+10 3 2022	0.04-01 3 2022	7.02+00 3 2022	1.07-02 3 2022	2.22+00 3 2122	1.21-02 3 2022	2.27-01 3 2022	1.10+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0.61+10 3 2022	22
0.07+10 3 2017	1.01+00 3 2017	1.10+01 3 2017	3.03-03 3 2017	2.00+00 3 2117	2.02-02 3 2017	0.04-01 3 2017	1.00+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	1.00+11 3 2017	23
3.47-11 3 2023	4.45+01 3 2023	5.67+01 3 2023	1.49-01 3 2023	0.00+00 3 2123	0.00-02 3 2023	2.40-00 3 2023	1.30+01 3	0000	0000	0000	0000	0000	2001	1.00+00 3 2070	0.00+00 3 2070	24
0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3 2124	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3	0000	1.00-01 3 2071	0000	0000	0000	2003	1.00+00 3 2124	0.00+00 2 0007	25
																26
0000	1.72-01 3 2032	4.00+00 3 2032	3.07-01 3 2032	4.00-01 3 2032	2.00+00 3 2032	7.94-02 3 2032	8.07+00 3	0000	3.72-01 3 2041	0.00-01 3 2042	0.30-03 3 2042	1.00-01 3 2042	2007	1.00+00 3 2001	3.00+00 3 2001	27
0000	2.75-02 3 2032	3.37-01 3 2032	0.10-01 3 2032	1.00-02 3 2032	0.10-03 3 2032	3.30-03 3 2032	0.10-01 3	0000	1.00-01 3 2071	0000	0000	0000	2006	1.00+00 3 2127	6.07+10 3 2002	28
0000	3.75-02 3 2032	3.37-01 3 2032	0.10-01 3 2032	1.00-02 3 2032	0.10-03 3 2032	3.30-03 3 2032	0.10-01 3	0000	1.00-01 3 2071	0000	0000	0000	2005	1.00+00 3 2127	6.07+10 3 2002	29
0000	3.02+00 3 2032	2.17+00 3 2032	2.21+00 3 2032	1.00+00 3 2032	1.00+00 3 2032	1.00-01 3 2032	1.00-01 3	0000	1.00-01 3 2071	0000	0000	0000	2000	1.00+00 3 2002	2.07+10 3 2002	30
0000	0.50-01 3 2032	1.07+01 3 2032	1.27+00 3 2032	1.07+00 3 2032	1.10+01 3 2032	3.04-01 3 2032	3.43+01 3	0000	3.03+03 3 2050	0000	0000	0000	2003	0000	1.41+10 3 2030	31
0000	1.20+00 3 2032	3.04+00 3 2032	3.33+00 3 2032	3.50+00 3 2032	2.50+00 3 2032	5.00-01 3 2032	1.32+01 3	0000	1.00+01 3 2000	0000	0000	0000	2003	0000	1.46+10 3 2030	32
																33
0000	0000	0000	0000	1.00+00 3 2130	0000	0000	1.00+00 3 2130	0000	1.72-01 3 2005	0000	0000	0000	2000	1.00+00 3 2130	0.00+00 3 0007	34
																35
0000	0000	0000	0000	0.00+00 3 2130	0000	0000	0.00+00 3 2130	0000	0.0	0000	0000	0000	2000	1.00+00 3 2130	0.00+00 3 0007	36
																37
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TABLE 20. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED IMPORTED CANADIAN CRUDE REGION OF OIL SUPPLY

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2306

BASED ON (2019,1/13), CANADIAN CRUDE OIL HAS AN AVERAGE SULFUR CONTENT OF 0.59 PC. BASED ON 3.2 PC OF THE S IN THE CRUDE BEING DISCHARGED FROM THE CAT CRACKER REGENERATOR (FOOTNOTE 2107),THE CAT CRACKER SO2 EMISSION FOR A 178000 BBL/YR REFINERY (1.0E12 BTU/YR) IS 9.94 TON SO2/YR. BASED ON 48.8 PC OF THE S IN THE CRUDE AS H2S IN THE REFINERY PROCESS GAS (FOOTNOTE 2066),WITH .3 TON S EMITTED IN THE COMBUSTION OF THIS PROCESS GAS (FOOTNOTE 2101), AND WITH A 99.9 PC RECOVERY OF THE S IN THE PROCESS GAS SENT TO THE CLAUS PLANT AND TAIL-GAS UNIT (FOOTNOTE 2101), .15 TON OF SO2 ARE DISCHARGED YEARLY FROM THE CLAUS UNIT. FUEL COMBUSTION SO2 EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2101 AND ARE LIMITED BY REGULATIONS.

2307

LAND REQUIREMENTS FOR PRINCIPAL SULFUR RECOVERY PROCESS EQUIPMENT, STORAGE, INCINERATOR AND STACK,CHANGES TO 2.82E-04 ACRES (FROM FOOTNOTE 2105) AND RESULTS IN A TOTAL INCREMENTAL LAND REQUIREMENT FOR CONTROLS ON A 1.0E12 BTU/YR REFINERY OF 2.05E-02 ACRES. THIS IS PROVIDED FOR IN THE REFINERY FIGURE GIVEN IN FOOTNOTE 2040.

2308

BASED ON FOOTNOTE 2125 AND 0.59 PC S IN THE CRUDE, THE ENERGY REQUIREMENT FOR OPERATION OF THE CLAUS PLANT AND TAIL-GAS UNIT IS 1.66E08 BTU/YR. FROM FOOTNOTE 2125 THE ANCILLARY ENERGY REQUIREMENT FOR A 1.0E12 BTU/YR REFINERY CHANGES TO 5.04E10 BTU/YR.

2309

FROM FOOTNOTE 2306,THE CAT CRACKER SO2 EMISSION FOR A 1.0E12 BTU/YR REFINERY IS 9.94 TON SO2/YR. FOR 1.0E12 BTU/YR INPUT TO THE CAT CRACKER MULTIPLY THIS BY 1.98 (FOOTNOTE 2107).

		UNCONTROLLED		1	2	3	4	5	6	7	8	9	10	11	12	13
		FUEL	REGION													
		OIL	IMPORTED MIDDLE EAST CRUDE	WATER POLLUTANTS (TONS/10^{12} BTU, EX COL 12)												
ROW	MNE-MON	ACTIVITY PROCESS		ACIDS	BASES	DISSOLVED SOLIDS				SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES
						PO_4	NO_3	OTHER	TOTAL (DS)							
1	TRNSP	CRUDE OIL TRANSPORT														
2	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	8.00-02 5 2001	8.00-02 5	0000	0000	0000	1.72-01 3 2021
3	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	4.00+01 2 2026	3.00+01 2	0000	0000	0000	3.75-02 3 2024
4	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	3.00-01 2 2026	3.00-01 5	0000	0000	0000	3.75-02 3 2025
5	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.65+00 2 2027	7.65+00 3	0000	0000	0000	3.02+00 3 2026
6	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.38-01 3 2026
7	TNKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2026
8	PROCS	PROCESSING														
9	NAVRG	NATIONAL AVERAGE REFINERY		0000	0000	0000	0000	1.45+00 2 2066	3.58+01 5 2066	2.22+01 2 2066	6.60+00 2 2066	6.40+01 3	6.02+00 2 2066	2.02+01 2 2066	7.00+10 4 2066	9.10+00 3 2066
10	CRDTK	CRUDE OIL STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 2 2066	0000	0.00+00 2 0097	0.00+00 2 0097
11	DESLT	ELECTROSTATIC DESALTING		0000	0000	0000	0000	1.02+01 3 2005	2.71+01 3 2005	0000	1.07+00 3 2005	2.34+01 4	2.07+01 3 2005	2.05+10 3 2005	0.00+00 2 0097	0000
12	DSTIL	ATMOS & VAC DISTILLATION		0000	0000	0000	0000	8.90-02 3 2006	3.12+00 3 2006	0000	1.60+00 3 2006	4.72+00 4	1.78-02 3 2006	4.45-01 4 2006	1.50+10 3 2006	2.07-01 3 2006
13	CATCR	CATALYTIC CRACKING		0000	0000	0000	0000	6.89+00 3 2007	7.92+00 3 2007	0000	9.24+00 3 2007	1.72+01 4	1.32+00 3 2007	1.58+00 3 2007	1.74+10 3 2007	5.68+00 3 2007
14	CATRF	CATALYTIC REFORMING		0000	0000	0000	0000	9.50-02 3 2008	1.18+01 3 2008	0.00+00 3 0097	4.02+00 3 2008	6.01+00 3	0.00+00 3 0097	3.80+00 3 2008	5.91+09 3 2008	3.32-01 3 2008
15	DSTHT	DISTILLATE HYDROTREATING		0000	0000	0000	0000	2.72+00 3 2009	3.01+00 3 2009	0.00+00 3 0097	8.60-04 3 2009	3.01+00 3	3.00-01 3 2009	4.50+00 3 2009	5.37+08 3 2009	1.46-02 3 2009
16	COKDG	DELAYED COKING		0000	0000	0000	0000	0000	2.34+00 3 2010	0000	4.93-01 3 2010	2.00+00 3	0000	2.54+00 3 2010	1.72+10 3 2010	5.20-01 3 2010
17	DSTHC	DISTILLATE HYDROCRACKING		0000	0000	0000	0000	1.72-01 3 2011	1.72-01 3 2011	0000	0000	1.72-01 5	1.72-01 3 2011	3.87+00 3 2011	1.43+10 3 2011	2.72-01 3 2011
18	REFRM	REFORMATION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.25+00 3 2012	1.05-01 3 2012
19	ALKYL	ALKYLATION		0000	0000	0000	0000	2.37+00 3 2013	3.56+01 3 2013	0000	1.05-02 3 2013	3.56+01 4	1.19+00 3 2013	1.15+01 3 2013	.04+11 3 2013	8.25-01 3 2013
20	AROMX	AROMATICS EXTRACTION		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.16+10 3 2014	2000
21	FURFR	FURFURAL REFINING		0000	0000	0000	0000	0000	0000	0000	2.48-01 3 2015	2.48-01 5	0000	0000	3.44+10 3 2015	5.42-01 3 2015
22	SLDWX	SOLVENT DEWAXING		0000	0000	0000	0000	0000	0000	0000	1.24-01 3 2016	1.24-01 5	2.06+01 3 2016	0000	7.80+10 3 2016	5.50-01 3 2016
23	SGTRT	SOUR GAS TREATING		0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2018	1.25+00 5	6.23+00 3 2018	0000	6.13+04 3 2018	8.09-03 3 2018
24	GASTR	GASOLINE TREATING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2019	0.00+00 3 2019
25	LUBFG	LUBE OIL HYDROTREATING		0000	0000	0000	0000	2.64+00 3 2020	2.80+00 3 2020	0.00+00 3 0097	6.25-04 3 2020	2.68+00 3	6.25-01 3 2020	4.13+00 3 2020	2.76+10 3 2020	3.62-01 3 2020
26	GREAS	GREASE MANUFACTURE		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
27	WXDGL	WAX DEGOLING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.34-01 3 2022
28	PROPA	PROPANE DEASPHALTING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.07+10 3 2017	1.01+00 3 2017
29	H2MFG	HYDROGEN MANUFACTURING		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.47+11 3 2023	4.45+00 3 2023
30	RFSTO	REFINERY PRODUCT STORAGE		0000	0000	0000	0000	0000	0000	0000	0000	0000	9.13-02 3 2037	0000	0.00+00 2 0097	0.00+00 2 0097
31	DSTRB	PRODUCT DISTRIBUTION														
32	PIPEL	PIPELINE		0000	0000	0000	0000	0000	0000	0000	6.22-02 5 2062	6.22-02 5	0000	0000	0000	1.12-01 3 2032
33	TANKR	TANKERS		0000	0000	0000	0000	0000	0000	0000	3.08+01 2 2063	3.08+01 2	0000	0000	0000	3.75-02 3 2032
34	SUPER	SUPERTANKERS		0000	0000	0000	0000	0000	0000	0000	3.08+01 2 2063	3.08+01 2	0000	0000	0000	3.75-02 3 2032
35	BARGE	BARGES		0000	0000	0000	0000	0000	0000	0000	7.66+00 2 2064	7.66+00 2	0000	0000	0000	3.02+00 3 2032
36	TNKTR	TANK TRUCKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	6.38-01 3 2032
37	TNKCR	TANK CARS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032
38	PTERM	PRODUCT TERMINALS														
39	TNKST	STORAGE TANKS		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
40	MRKT	MARKETING														
41	GAST	AUTO GASOLINE TANK FILL		0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
42																
43																
44																
45																
46																
47																
48																
49																
50																

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
		AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
	THERMAL (BTU/10^{12}BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC	TOTAL	SOLIDS TONS/ 10^{12}BTU	LAND (ACRE-YR/ 10^{12} BTU)	DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12}BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12}BTU)	ROW
0000	0000	1.72-01 3 2031	4.69+00 3 2031	3.57-01 3 2031	4.90-01 3 2031	2.98+00 3 2031	7.94-02 3 2031	8.97+00 3	0000	8.36+01 2 2062	3.36-05 4 2034	7.79-03 4 2034	6.46-02 4 2034	2087	1.00+00 2 2081	3.59+08 2 2081	1
0000	0000	3.75-02 3 2024	3.37-01 3 2024	5.15-01 3 2024	1.80-02 3 2024	6.14-03 3 2024	3.35-03 3 2024	9.16-01 3	0000	1.61-01 3 2071	0000	0000	0000	2088	9.99-01 2 2082	3.87+10 2 2082	2
0000	0000	3.75-02 3 2025	3.37-01 3 2025	5.15-01 3 2025	1.80-02 3 2025	6.14-03 3 2025	3.35-03 3 2025	9.16-01 3	0000	1.61-01 3 2071	0000	0000	0000	2088	9.99-01 2 2082	3.87+10 2 2082	3
0000	0000	3.02+00 3 2028	2.17+00 3 2028	2.31+00 3 2028	1.40+00 3 2028	1.66+00 3 2028	1.09-01 3 2028	1.08+01 3	0000	1.61-01 3 2071	0000	0000	0000	2088	1.00+00 2 2083	2.52+10 2 2083	4
0000	0000	9.58-01 3 2029	1.87+01 3 2029	1.37+00 3 2029	1.67+00 3 2029	1.14+01 3 2029	3.04-01 3 2029	3.43+01 3	0000	1.52+02 3 2067	0000	0000	0000	2089	0000	1.38+10 2 2029	5
0000	0000	1.28+00 3 2030	3.86+00 3 2030	3.33+00 3 2030	2.38+00 3 2030	3.10+00 3 2030	5.69-01 3 2030	1.52+01 3	0000	1.88+01 3 2070	0000	0000	0000	2089	0000	1.42+10 2 2030	6
																	7
2000	7.00+10 4 2068	8.10+00 3 2000	2.28+01 3 2000	5.84+02 4 2208	2.32+02 3 2066	8.11+02 3 2066	3.73+00 3 2066	1.45+03 4	0.00+00 4 2000	1.03+01 4 2040	4.35-04 3 2041	5.62-02 3 2041	2.05+00 3 2041	2091	9.32-01 3 2093	5.88+10 2 2094	8
0000	0.00+00 2 0987	0.00+00 2 0987	0.00+00 2 0987	0.00+00 2 0987	6.72+01 3 2036	0.00+00 2 0987	0.00+00 2 0987	6.72+01 3	0000	1.61-01 3 2071	0000	0000	0000	2092	0.99-01 2 2080	0.00+00 2 0987	9
2000	0.00+00 2 0987	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	1.08+07 2 2005	10
2000	1.50+10 3 2006	2.[illegible]-01 3 2006	2.38+00 3 2006	6.21-03 3 2006	2.02+01 3 2006	6.14-03 3 2006	1.04-01 3 2006	1.09+01 3	0.00	0000	0000	0000	0000	2091	1.00+00 2 2078	2.21+10 2 2006	11
2000	1.74+10 3 2007	5.68+00 3 2007	9.07+00 3 2007	6.38+01 4 2207	3.72+01 3 2007	1.21+01 3 2007	6.57+00 3 2007	1.33+01 4	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	3.35+10 2 2007	12
2000	5.33+08 3 2008	3.32-01 3 2008	3.82+00 3 2008	9.87-03 3 2008	1.48+00 3 2008	6.65-03 3 2008	1.56-01 3 2008	1.81+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	4.35+10 2 2008	13
2000	5.37+08 3 2009	1.46-02 3 2009	1.67-01 3 2009	4.37-04 3 2009	1.38+01 3 2009	2.91-04 3 2009	7.27-03 3 2009	1.40+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	1.58+09 2 2009	14
2010	1.72+10 3 2010	5.20-01 3 2010	5.87+00 3 2010	1.56-02 3 2010	6.08+01 3 2010	1.04-02 3 2010	2.60-01 3 2010	1.74+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	6.17+10 2 2010	15
2011	1.43+10 3 2011	2.72-01 3 2011	7.13+00 3 2011	8.16-03 3 2011	1.38+01 3 2011	5.44-03 3 2011	1.36-01 3 2011	1.08+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	4.56+10 2 2011	16
0000	2.25+08 3 2012	1.95-01 3 2012	1.13+01 3 2012	5.63-03 3 2012	1.34+01 3 2012	3.88-03 3 2012	9.72-02 3 2012	2.50+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	2.33+10 2 2012	17
2013	1.04+11 3 2013	8.25-01 3 2013	8.50+00 3 2013	2.68-03 3 2013	5.11+01 3 2013	1.63-02 3 2013	4.13-01 3 2013	6.19+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	6.84+10 2 2013	18
0000	4.18+10 3 2014	0000	0000	0000	1.61+01 3 2014	0000	0000	1.61+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	0000	19
0000	3.44+10 3 2015	5.42-01 3 2015	8.23+00 3 2015	1.62-02 3 2015	7.21+00 3 2015	1.04-02 3 2015	2.71-01 3 2015	2.13 01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	0000	20
0000	7.60+10 3 2016	5.30-01 3 2016	6.32+00 3 2016	1.65-02 3 2016	1.90+01 3 2016	1.10-02 3 2016	2.74-01 3 2016	2.62+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	9.75+10 2 2016	21
0000	6.43+08 3 2018	8.00-03 3 2018	9.20-02 3 2018	2.40-04 3 2018	4.08+01 3 2018	1.60-04 3 2018	4.00-03 3 2018	4.01+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	7.89+10 2 2018	22
0000	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3 2019	0.00+00 3 2019	0.00+00 3 2019	1.21+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	1.67+04 2 2018	23
2020	2.70+10 3 2020	3.62-01 3 2020	4.10+00 3 2020	1.12-02 3 2020	1.38+01 3 2020	7.23-03 3 2020	1.81-01 3 2020	1.65+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	0000	24
0000	0000	0000	0000	0000	9.94+00 4 2021	0000	0000	9.94+00 3 2065	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	4.12+10 2 2020	25
0000	3.72+10 3 2022	6.54-01 3 2022	7.52+00 3 2022	1.87-02 3 2022	1.[illegible]+01 3 2022	1.31-02 3 2022	3.27-01 3 2022	2.04+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	0000	26
0000	4.87+10 3 2017	1.01+00 3 2017	1.16+01 3 2017	3.03-02 3 2017	1.1[illegible]+01 3 2017	2.02-02 3 2017	5.04-01 3 2017	3.43+01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	8.41+10 2 2022	27
0000	2.47+11 3 2023	4.45+00 3 2023	5.67+01 3 2023	1.49-01 3 2023	9.80+00 3 2023	9.80-03 3 2023	2.48-00 3 2023	7.38-01 3	0000	0000	0000	0000	0000	2091	1.00+00 2 2078	1.08+11 2 2017	28
0000	0.00+00 2 0987	0.00+00 2 0987	0.00+00 2 0987	0.00+00 2 0987	8.33+01 3 2037	0.00+00 2 0987	0.00+00 2 0987	8.33+01 3	0000	1.66-01 3 2071	0000	0000	0000	2092	9.98-01 2 2079	1.03+12 2 2079	29
																0.00+00 2 0987	30
																	31
0000	0000	1.72-01 3 2032	4.69+00 3 2032	3.57-01 3 2032	4.90-01 3 2032	2.98+00 3 2032	7.94-02 3 2032	8.97+00 3	0000	3.78+01 2 2060	6.00-05 3 2042	4.28-03 3 2042	1.00-01 3 2042	2087	1.00+00 2 2081	3.59+08 2 2081	32
0000	0000	3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.80-02 3 2032	6.14-03 3 2032	3.35-03 3 2032	9.16-01 3	0000	1.66-01 3 2071	0000	0000	0000	2088	9.99-01 2 2082	4.07+10 2 2082	33
0000	0000	3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.80-02 3 2032	6.14-03 3 2032	3.35-03 3 2032	9.16-01 3	0000	1.66-01 3 2071	0000	0000	0000	2088	9.99-01 2 2082	4.07+10 2 2082	34
0000	0000	3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032	1.40+00 3 2032	1.66+00 3 2032	1.09-01 3 2032	1.08+01 3	0000	1.66-01 3 2071	0000	0000	0000	2088	1.00+00 2 2083	2.57+10 2 2083	35
0000	0000	9.58-01 3 2032	1.87+01 3 2032	1.37+00 3 2032	1.67+00 3 2032	1.14+01 3 2032	3.04-01 3 2032	3.43+01 3	0000	1.63+02 3 2068	0000	0000	0000	2089	0000	1.41+10 3 2029	36
0000	0000	1.28+00 3 2032	3.86+00 3 2032	3.32+00 3 2032	2.38+00 3 2032	3.38+00 3 2032	5.68-01 3 2032	1.52+01 3	0000	1.89+01 3 2069	0000	0000	0000	2089	0000	1.46+10 2 2030	37
																	38
0000	0000	0000	0000	0000	3.80+01 3 2038	0000	0000	3.80+01 3	0000	1.73-01 2 2065	0000	0000	0000	2090	9.98-01 2 2080	0.00+00 2 0987	39
																	40
0000	0000	0000	0000	0000	4.80+01 3 2038	0000	0000	4.80+01 3	0000	0000	0000	0000	0000	2100	9.98-01 2 2080	0.00+00 2 0987	41
																	42
																	43
																	44
																	45
																	46
																	47
																	48
																	49
																	50

TABLE 21. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED IMPORTED MIDDLE EAST CRUDE REGION OF OIL SUPPLY

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2206

BASED ON (2019,1/13), MIDDLE EAST CRUDE OIL HAS AN AVERAGE SULFUR CONTENT OF 1.92P. USING THE NATIONAL AVERAGE OF 0.79P (FROM FOOTNOTE 2000) AS A STANDARD, THE MIDDLE EAST OIL CONTAINS 143P MORE SULFUR. FUEL OIL FROM THIS CRUDE WOULD CONTAIN 3.65P SULFUR AND PETROLEUM COKE WOULD CONTAIN 4.37P S. THE SOX EMISSIONS FROM THE CATALYTIC CRACKING OPERATION, AND FROM THE BURNING OF FUEL OIL, PETROLEUM COKE AND REFINERY GASES WILL INCREASE BY 143P. THESE INCREASES ARE

CAT. CRACKING SOX	1.91E+01 TON/YR
FUEL OIL COMBUSTION	1.19E+01
REFINERY GAS COMBUSTION	2.91E+02
PETROLEUM COKE COMBUSTION	2.23E+01

2207

SOX EMISSIONS WILL INCREASE BY 143P ABOVE THOSE FROM FOOTNOTE 2007 (SEE FOOTNOTE 2206). THIS INCREASE AMOUNTS TO 3.76E+01 TONS/YR.

CONTROLLED FUEL	REGION
OIL	IMPORTED MIDDLE EAST CRUDE

ROW	NOMEN-CLATURE	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL BTU/10^{12}BTU	13 PARTIC-ULATES	14
		WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)														
1	TRNSP	CRUDE OIL TRANSPORT														
2	PIPEL	PIPELINE	0000	0000	0000	0000	0000	0000	0000	0.00-02 3 2003	0.00-02 3	0000	0000	0000	1.72-01 3 2031	4.00+00
3	TANKR	TANKERS	0000	0000	0000	0000	0000	0000	0000	7.57+00 2 2129	7.57+00 3	0000	0000	0000	3.75-02 3 2024	3.37-01
4	SUPER	SUPERTANKERS	0000	0000	0000	0000	0000	0000	0000	7.57+00 3 2129	7.57+00 3	0000	0000	0000	3.75-02 3 2025	3.37-01
5	BARGE	BARGES	0000	0000	0000	0000	0000	0000	0000	7.65+00 2 2027	7.65+00 3	0000	0000	0000	3.02+00 3 2026	2.17+00
6	TNKTR	TANK TRUCKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.58-01 3 2028	1.07+01
7	TNKCR	TANK CARS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2030	3.84+00
8	PROCE	PROCESSING														
9	NAVRF	NATIONAL AVERAGE REFINERY	0000	0000	0000	0000	3.02-01 3 2100	3.60+01 3 2100	0.00-01 3 2100	3.80-01 3 2100	3.50+01 3	0.00-01 3 2100	0.00+00 3 2100	0.00+00 3 2100	2.73+00 3 2101	1.07+01
10	CRDTK	CRUDE OIL STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00-01 3 2030	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00
11	DSALT	ELECTROSTATIC DESALTING	0000	0000	0000	0000	1.02+01 3 2005	2.23-01 3 2005	0000	1.07+00 3 2005	2.34+01 4	2.07-01 4 2005	2.05+00 3 2005	0.00+00 2 0007	2005	
12	DSTIL	ATMOS. & VAC. DISTILLATION	0000	0000	0000	0000	6.90-02 3 2006	3.12+00 3 2005	0000	1.60+00 3 2006	4.72+00 4	1.78-02 3 2006	4.43-01 3 2006	1.50+10 3 2006	2.07-01 3 2006	2.30+00
13	CATCR	CATALYTIC CRACKING	0000	0000	0000	0000	6.69+00 3 2007	7.92+00 3 2007	0000	9.24+00 3 2007	1.72+01 4	1.32+00 3 2007	1.38+00 3 2007	1.74+10 3 2007	1.50+00 3 2107	9.07+00
14	CATRF	CATALYTIC REFORMING	0000	0000	0000	0000	9.50-02 3 2008	1.18+01 3 2008	0.00+00 3 0007	4.62+00 3 2008	6.01+00 3	0.00+00 3 0007	3.80+00 3 2008	5.93+00 3 2008	3.52-01 3 2008	3.02+00
15	DSTHT	DISTILLATE HYDROTREATING	0000	0000	0000	0000	2.72+00 3 2 [illegible]	3.01+00 3 2009	0.00+00 3 0007	8.60-04 3 2009	3.01+00 3	8.60-01 3 2009	6.30+00 3 2009	5.37+09 3 2009	1.46-02 3 2009	1.67-01
16	COKG	DELAYED COKING	0000	0000	0000	0000	0000	7.39+00 3 2010	0000	4.93-01 3 2010	2.86+00 3	1000	2.56+00 3 2010	1.72+10 3 2010	5.20-01 3 2010	5.07+00
17	DSTHC	DISTILLATE HYDROCRACKING	0000	0000	0000	0000	1.72-11 3 2011	1.72-01 3 2011	0000	0000	1.7[illegible]-01 5	1.72-01 3 2011	3.07+00 3 2011	1.43+10 3 2011	2.77-01 3 2011	3.13+00
18	ISOMR	ISOMERIZATION	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.25+08 3 2012	1.85-01 3 2012	1.13+01
19	ALKYL	ALKYLATION	0000	0000	0000	0000	2.37+00 3 2013	3.56+01 3 2013	0000	1.19-02 3 2013	3.58+01 4	1.10+00 3 2013	1.10-01 3 2013	1.04+11 3 2013	8.25-01 3 2013	8.50+00
20	AROMA	AROMATICS EXTRACTION	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.16+10 3 2014	0000	
21	FURFR	FURFURAL REFINING	0000	0000	0000	0000	0000	0000	0000	2.48-01 3 2015	2.48-01 5	0000	0000	3.44+10 3 2015	5.42-01 3 2015	6.23+00
22	FLDWX	SOLVENT DEWAXING	0000	0000	0000	0000	0000	0000	0000	1.24-01 3 2016	1.24-01 5	2.06+01 3 2016	0000	7.06+10 3 2016	5.50-01 3 2016	6.32+00
23	SGTRT	SOUR GAS TREATING	0000	0000	0000	0000	0000	0000	0000	1.25+00 3 2018	1.25+00 5	6.23+00 3 2018	0000	6.43+08 3 2018	6.00-03 3 2018	8.20-00
24	GASTR	GASOLINE TREATING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 2018	0.00+00 3 2018	0.00+00
25	LUBRC	LUBE OIL HYDROTREATING	0000	0000	0000	0000	2.64+00 3 2020	2.64+00 3 2020	0.00+00 3 0007	8.25-04 3 2020	2.03+00 3	8.25-01 3 2020	6.13+00 3 2020	2.78+10 3 2020	3.02-01 3 2020	4.10+00
26	GREAS	GREASE MANUFACTURE	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
27	WXDCR	WAX DEOILING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.77+10 3 2022	6.54-01 3 2022	7.53+00
28	PROPA	PROPANE DEASPHALTING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	4.87+10 3 2017	1.01+00 3 2017	1.10+01
29	HDRPC	HYDROGEN MANUFACTURING	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.47-11 3 2023	4.45+00 3 2023	5.67+01
30	RFSTO	REFINERY PRODUCT STORAGE	0000	0000	0000	0000	0000	0000	0000	0000	0000	0.15-02 3 2037	0000	0.00+00 2 0007	0.00+00 2 0007	0.00+00
31	DISTR	PRODUCT DISTRIBUTION														
32	PIPEL	PIPELINE	0000	0000	0000	0000	0000	0000	0000	0.[illegible]-02 3 2003	0.22-01 3	0000	0000	0000	1.72-01 3 20[illegible]	4.00+00
33	TANKR	TANKERS	0000	0000	0000	0000	0000	0000	0000	0.07+00 2 2127	0.07+00 3	0000	0000	0000	3.75-02 3 2032	3.37-01
34	SUPER	SUPERTANKERS	0000	0000	0000	0000	0000	0000	0000	0.07+00 2 2127	0.07+00 3	0000	0000	0000	3.75-02 3 2032	3.37-01
35	BARGE	BARGES	0000	0000	0000	0000	0000	0000	0000	[illegible]	[illegible]	0000	0000	0000	3.02+00 3 2032	2.17+00
36	TNKTR	TANK TRUCKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.58-01 3 2032	1.07+01
37	TNKCR	TANK CARS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.28+00 3 2032	3.84+00
38	PTERM	PRODUCT TERMINALS														
39	TNKST	STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
40	MRKT	MARKETING														
41	GAST	AUTO GASOLINE TANK FILL	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
42																
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

HITTMAN

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	ROW
THERMAL BTU/10^{12}BTU	AIR POLLUTANTS (TONS/10^{12} BTU) PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12}BTU)	LAND (ACRE-YR/10^{12} BTU)	OCCUPATIONAL HEALTH DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12}BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12}BTU	
																1
0000	1.72-01 3 2031	4.80+00 3 2031	3.57-01 3 2031	4.00-01 3 2031	2.98+00 3 2031	7.04-02 3 2031	6.97+00 3	0000	6.39+01 2 2002	3.30-05 4 2034	2.70-03 4 2034	6.46-02 4 2034	2007	1.00+00 2 2001	3.59+00 2 2001	2
0000	3.75-02 3 2024	3.27-01 3 2024	5.15-01 3 2024	1.00-02 3 2024	6.14-03 3 2024	3.35-03 3 2024	9.18-01 3	0000	1.61-01 3 2071	0000	0000	0000	2000	1.00+00 2 2139	3.07+10 2 2002	3
0000	3.75-02 3 2025	3.37-01 3 2025	5.15-01 3 2025	1.00-02 3 2025	6.14-03 3 2025	3.35-03 3 2025	9.18-01 3	0000	1.61-01 3 2071	0000	0000	0000	2000	1.00+00 2 2139	3.07+10 3 2002	4
0000	3.02+00 3 2020	2.17+00 3 2020	2.31+00 3 2020	1.40+00 3 2020	1.86+00 3 2020	1.00-01 3 2020	1.00+01 3	0000	1.61-01 3 2071	0000	0000	0000	2000	1.00+00 2 2043	2.32+10 2 2002	5
0000	6.58-01 3 2020	1.07+01 3 2020	1.37+00 3 2020	1.07+00 3 2020	1.14+01 3 2020	3.04-01 3 2020	3.63+01 3	0000	3.52+02 3 2007	0000	0000	0000	2000	0000	1.38+10 3 2020	6
0000	1.20+00 3 2030	3.04+00 3 2030	3.23+00 3 2030	2.56+00 3 2030	3.50+00 3 2030	5.00-01 3 2030	1.52+01 3	0000	1.90+01 3 2070	0000	0000	0000	2000	0000	1.43+10 3 2030	7
																8
0000 2 2101	2.73+00 3 2101	1.07+01 3 2101	4.03+01 3 2310	2.76+01 3 2101	1.68+01 3 2101	3.71+00 3 2101	9.02+01 3	4.27+01 4 2101	1.03+01 4 2311	4.20-04 3 2041	3.02-02 3 2041	7.05-00 3 2041	2001	0.00-01 3 2000	5.07+10 3 2312	9
0000 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 2123	0.00+00 2 0007	0.00+00 2 0007	0.00+00 3	0000	1.61-01 3 2071	0000	0000	0000	2002	1.00+00 2 2123	0.00+00 2 0007	10
0000 2 0007	2005	2005	2005	2005	2005	2005	2005	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.00+07 3 2000	11
0000 3 2006	2.07-01 2 2006	2.50-00 3 2006	6.21-02 3 2006	0.00+00 3 2100	4.14-03 3 2006	1.04-01 3 2006	0.00+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	2.21+10 3 2006	12
0000 3 2107	1.50+00 3 2107	9.07+00 3 2107	1.60+01 3 2311	3.00+00 3 2107	2.70-01 3 2107	0.07+00 3 2107	4.30+01 3	4.17+00 3 2107	0000	0000	0000	0000	2001	1.00+00 2 2078	9.01+10 2 2107	13
0000 3 2008	3.32-01 3 2008	3.82+00 3 2008	9.82-03 3 2008	0.00+00 3 2100	6.65-03 3 2008	1.50-01 3 2008	7.30+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	4.35+10 2 2008	14
0000 3 2009	1.46-02 3 2009	1.67-01 3 2009	4.37-04 3 2009	2.32+00 3 2100	2.91-04 3 2009	7.27-03 3 2009	2.67+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.50+08 2 2009	15
0000 3 2010	5.10-01 3 2010	5.97+00 3 2010	1.96-02 3 2010	2.77+00 3 2110	1.04-02 3 2010	2.60-01 3 2010	9.55+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	6.17+10 3 2010	16
0000 3 2011	2.72-01 3 2011	3.15+00 3 2011	8.10-03 3 2011	2.62+00 3 2111	5.44-03 3 2011	1.36-01 3 2011	8.17+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	6.58+10 2 2011	17
0000 3 2012	1.05-01 3 2012	1.13+01 3 2012	5.03-03 3 2012	2.07+00 3 2112	2.68-03 3 2012	9.72-02 3 2012	1.40+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	2.33+10 2 2012	18
0000 3 2013	8.25-01 3 2013	9.50+00 3 2013	2.46-03 3 2013	9.93+00 3 2113	1.65-02 3 2013	4.12-01 3 2013	1.83+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0.00+00 2013	19
0000 3 2014	0000	0000	0000	2.04+00 3 2114	0000	0000	2.04+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0000	20
0000 3 2015	5.42-01 3 2015	8.23+00 3 2015	1.42-02 3 2015	2.00+00 3 2115	1.00-02 3 2015	2.71-01 3 2015	1.01+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	9.73+10 2 2015	21
0000 3 2016	5.30-02 3 2016	6.32+00 3 2016	1.65-02 3 2016	3.18+00 3 2116	1.10-02 3 2016	2.74-01 3 2016	1.06+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	7.00+10 2 2016	22
0000 3 2018	0.00-03 3 2018	0.20-02 3 2018	2.60-04 3 2018	4.04+00 3 2118	1.60-04 3 2018	4.00-03 3 2018	4.14+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.67+09 2 2018	23
0000 3 2019	0.00+00 3 2019	0.00+00 3 2019	0.00+00 3 2019	2.67+00 3 2119	0.00+00 3 2019	0.00+00 3 2019	2.67+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0000	24
0000 3 2020	3.02-01 3 2020	4.16+00 3 2020	1.12-02 3 2020	2.71+00 3 2120	7.22-03 3 2020	1.81-01 3 2020	7.43+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	4.13+10 2 2020	25
0000	0000	0000	0000	2.03+00 3 2121	0000	0000	2.03+00 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	0000	26
0000 3 2022	6.54-01 3 2022	7.53+00 3 2022	1.97-02 3 2022	5.22+00 3 2122	1.21-02 3 2022	3.27-01 3 2022	1.10+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	8.41+10 2 2022	27
0000 3 2017	1.01-00 3 2017	1.10+01 3 2017	3.03-02 3 2017	9.00+00 3 2117	2.02-02 3 2017	5.04-01 3 2017	1.05+01 3	0000	0000	0000	0000	0000	2001	1.00+00 2 2078	1.00+11 2 2017	28
0000 3 2023	4.45+00 3 2023	5.67-01 3 2023	1.40-01 3 2023	2.00+00 3 2123	3.80-02 3 2023	2.40-00 3 2023	7.18-01 3	0000	0000	0000	0000	0000	2001	2.03-01 2 2078	7.03+12 2 2078	29
0000 2 0007	0.00+00 2 0007	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3 2124	0.00+00 2 0007	0.00+00 2 0007	7.30+00 3	0000	1.00-01 3 2071	0000	0000	0000	2002	1.00+00 2 2124	0.00+00 2 0007	30
																31
0000	1.72-01 3 2032	4.80+00 3 2032	3.57-01 3 2032	4.00-01 3 2032	2.98+00 3 2032	7.04-02 3 2032	6.97+00 3	0000	3.79+01 2 2000	0.90-03 3 2042	4.20-03 3 2042	1.00-01 3 2042	2007	3.00+00 2 2001	3.60+00 2 2001	32
0000	3.75-02 3 2032	3.27-01 3 2032	5.15-01 3 2032	1.00-02 3 2032	6.14-03 3 2032	3.35-03 3 2032	9.18-01 3	0000	1.60-01 3 2071	0000	0000	0000	2000	1.00+00 2 2127	4.07+10 2 2002	33
0000	3.75-02 3 2032	3.37-01 3 2032	5.15-01 3 2032	1.00-02 3 2032	6.14-03 3 2032	3.35-03 3 2032	9.18-01 3	0000	1.60-01 3 2071	0000	0000	0000	2000	1.00+00 2 2127	4.07+10 3 2002	34
0000	3.02+00 3 2032	2.17+00 3 2032	2.31+00 3 2032	1.40+00 3 2032	1.86+00 3 2032	1.00-01 3 2032	1.00+01 3	0000	1.60-01 3 2071	0000	0000	0000	2000	1.00+00 2 2003	2.32+10 3 2002	35
0000	6.58-01 3 2032	1.07+01 3 2032	1.37+00 3 2032	1.07+00 3 2032	1.14+01 3 2032	3.04-01 3 2032	3.63+01 3	0000	3.62+02 3 2000	0000	0000	0000	2000	0000	1.41+10 3 2030	36
0000	1.20+00 3 2032	3.04+00 3 2032	3.23+00 3 2032	2.56+00 3 2032	3.50+00 3 2032	5.00-01 3 2032	1.52+01 3	0000	1.90+01 3 2000	0000	0000	0000	2000	0000	1.46+10 3 2030	37
																38
0000	0000	0000	0000	1.69+00 2 2128	0000	0000	1.69+00 2 2128	0000	1.73-01 2 2085	0000	0000	0000	2000	1.00+00 2 2128	0.00+00 2 0007	39
																40
0000	0000	0000	0000	5.00+00 3 2129	0000	0000	5.00+00 2 2129	0000	0000	0000	0000	0000	2000	1.00+00 2 2128	0.00+00 2 0007	41
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TABLE 22. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED IMPORTED MIDDLE EAST CRUDE REGION OF OIL SUPPLY

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2310

BASED ON (2019,1/13), MIDDLE EAST CRUDE OIL HAS AN AVERAGE SULFUR CONTENT OF 1.92 PC. BASED ON 3.2 PC OF THE S IN THE CRUDE BEING DISCHARGED FROM THE CAT CRACKER REGENERATOR (FOOTNOTE 2107),THE CAT CRACKER SO2 EMISSION FOR A 178000 BBL/YR REFINERY (1.0E12 BTU/YR) IS 32.3 TON SO2/YR. BASED ON 48.8 PC OF THE S IN THE CRUDE AS H2S IN THE REFINERY PROCESS GAS (FOOTNOTE 2066),WITH .3 TON S EMITTED IN THE COMBUSTION OF THIS PROCESS GAS (FOOTNOTE 2101), AND WITH A 99.9 PC RECOVERY OF THE S IN THE PROCESS GAS SENT TO THE CLAUS PLANT AND TAIL-GAS UNIT (FOOTNOTE 2101), .49 TON OF SO2 ARE DISCHARGED YEARLY FROM THE CLAUS UNIT. FUEL COMBUSTION SO2 EMISSIONS ARE THE SAME AS GIVEN IN FOOTNOTE 2101 AND ARE LIMITED BY REGULATIONS.

2311

LAND REQUIREMENTS FOR PRINCIPAL SULFUR RECOVERY PROCESS EQUIPMENT, STORAGE, INCINERATOR, AND STACK CHANGES TO 9.16E-04 ACRES(FROM FOOTNOTE 2105) AND RESULTS IN A TOTAL INCREMENTAL LAND REQUIREMENT FOR CONTROLS ON A 1.0E12 BTU/YR REFINERY OF 2.12E -02 ACRES. THIS IS PROVIDED FOR IN THE REFINERY FIGURE GIVEN IN FOOTNOTE 2040.

2312

BASED ON FOOTNOTE 2125 AND 1.92 PC S IN THE CRUDE, THE ENERGY REQUIREMENT FOR OPERATION OF THE CLAUS PLANT AND TAIL-GAS UNIT IS 5.40E08 BTU/YR. FROM FOOTNOTE 2125 THE ANCILLARY ENERGY REQUIREMENT FOR A 1.0E12 BTU/YR REFINERY CHANGES TO 5.07E10 BTU/YR.

2313

FROM FOOTNOTE 2310,THE CAT CRACKER SO2 EMISSION FOR A 1.0E12 BTU/YR REFINERY IS 32.3 TON SO2/YR. FOR 1.0E12 BTU/YR INPUT TO THE CAT CRACKER MULTIPLY THIS BY 1.98 (FOOTNOTE 2107).

FUEL	REGION
OIL	IMPORTED S.A. RESIDUAL F.O.

			1	2	3	4	5	6	7	8	9	10	11	12	13	14
			WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL. 12)													
					DISSOLVED SOLIDS											
ROW	MNE-MON.	ACTIVITY PROCESS	ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,9	BOD	COD	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO.
1	TRNSP	RESID TRANSPORT														
2	TANKR	TANKER	0000	0000	0000	0000	0000	0000	0000	2.10-01 3 2208	2.10-01 5	0000	0000	0000	3.71-02 3 1288	3.37-01
3	PTERM	PRODUCT TERMINAL														
4	TNKST	STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.92-02 4 2212	0000	0.00+00 1 0097	0.00+00 1 0097	0.00+00
5																
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL BTU/10^{12}BTU	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/ 10^{12}BTU	LAND (ACRE-YR/ 10^{12} BTU)	DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12}BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12}BTU	ROW
																1
0000 0 9	3.79-02 3 2206	3.37-01 3 2200	7.71-01 3 2206	1.96-02 3 2206	6.14-03 3 2206	3.35-03 3 2206	1.17+00 3	0000	0000	0000	0000	0+00	2000	9.99-01 2 2211	6.56+09 2 2210	2
																3
0000 0.00+00 1 0007	5.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0000	7.23-02 3 2209	0000	0000	0000	2002	1.00+00 2 2000	0.00+00 1 0007	4
																5
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																8
																9
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TABLE 23. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE UNCONTROLLED SOUTH AMERICAN RESIDUAL REGION OF OIL SUPPLY

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2208

THE MAJOR SUPPLIER OF SOUTH AMERICAN RESIDUAL FUEL OIL TO THE U.S. IS VENEZUELA WITH 36P(1.92E08 BBLS) OF THE TOTAL RESID IMPORT. BY THE U.S. IN 1971(2020,12). VENEZUELAN RESID WAS IMPORTED TO THE U.S. WITH THE FOLLOWING SULFUR DISTRIBUTION,BASED ON (2020,42)

PERCENT (WT) SULFUR	BBLS	VOL (PC)
LESS THAN 0.3	6,079,000	3.2
0.31-0.50	9,490,000	5.0
0.51-1.00	45,906,000	24.0
1.01-2.00	37,500,000	19.6
GREATER THAN 2.00	92,505,000	48.2

BASED ON THE ABOVE DISTRIBUTION,THE AVERAGE SULFUR CONTENT OF IMPORTED SOUTH AMER. RESID IS 1.50P(WT). FROM(2020,13),RESID IS GENRL. CONSUMED IN THE VICINITY OF THE PORT OF ENTRY INTO THE U.S. THE PRINCIPAL PORT OF ENTRY IS NEW YORK HARBOR WHICH RECEIVED 26P OF THE NATION'S RESID IMPORTS IN 1971(2020,13). FROM(0005,38) RESID HAS A HTG VALUE OF 6.287E06 BTU/BBL AND FROM(0010,588) RESIDUAL DENSITY IS 6.04 BBL/TON. THUS 1.0E12 BTU/YR RESID IS EQUIV. TO 159000 BBL/YR.

TRANSPORTATION OF RESID FROM VENEZ. TO NYC IS BY TANKER. THE ROUNDTRIP DISTANCE FROM VENEZUELA TO NYC IS APPROXIMATELY 4000 MILES, HOWEVER ONLY THOSE AIR AND WATER POLLUTANTS ASSOCIATED WITH 100 MILES OF TRAVEL WITHIN THE U.S. COASTAL WATERS ARE ASSUMED TO HAVE ANY ENVIRONMENTAL IMPACTS. FROM FOOTNOTE 2024, THE FOLLOWING ASSUMPTIONS ARE ALSO USED IN DETERMINING THE ENVIRONMENTAL IMPACTS OF RESID TRANSPORT BY TANKER

(1) TANKER SIZE IS IN THE 45000 DWT CLASS. BASED ON(2007, 10-7), THE TANKER CAPACITY IS 396000 BBL, SPEED IS 16 KNOTS, UNLOADING CAPACITY IS 20000 BPH, UNLOADING TIME IS 19.8 HRS.

(2) FUEL OIL FOR STEAMSHIPS CONTAINS 1.5P S,BASED ON AVERAGE SULFUR CONTENT OF RESID TRANSPORTED.

(3) EMISSION FACTORS FOR STEAMSHIPS UNDERWAY AND IN-BERTH FROM(0002,3-11)

(4) TUGBOAT EMISSIONS BASED ON FOOTNOTE 2024

(5) ACTUAL UNLOADING TIME FOR 159000 BBLS RESID IS 8 HOURS BASED ON ASSUMPTION(1). TOTAL IN-BERTH TIME IS ASSUMED TO BE 24 HRS.

AIR POLLUTANTS (TONS/YR)

COMPONENT	COASTAL EMISSIONS	IN-BERTH EMISSIONS	TUGBOAT EMISSIONS
PARTICULATES	2.00E-02	7.50E-03	1.00E-02
SOX	5.33E-01	2.30E-01	7.50E-03
CO	1.00E-04	4.00E-05	6.00E-03
HC	1.00E-02	4.50E-03	4.50E-03
NOX	2.30E-01	1.00E-01	7.00E-03
ALDEHYDES	2.00E-03	1.00E-03	3.50E-04

WATER POLLUTANTS

FROM(0020,1/8) TANKERS LOSE APPROXIMATELY 0.11P OF THEIR CARGOES IN DISCHARGES, LEAKS AND SPILLS. THIS IS ASSUMED TO OCCUR WITHIN THE COASTAL WATERS OF THE U.S.

2209

FROM FOOTNOTE 2071, FOR A STORAGE FACILITY HANDLING 2.2E09 BBLS/YR, ABOUT 2000 AC ARE REQUIRED. 1.0E12 BTU/YR EQUIVALENT OF RESID IS 159000. AC FOUND BY RATIO.

2210

FROM FOOTNOTE 2208 AVERAGE LADEN TRIP IS 2000 MI. FROM FOOTNOTE 2082 TANKER ENERGY IS 930 TMI/GAL. 159000 BBL/YR RESID IS

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FTN. 2211-2212
EQUIVALENT TO 26325 TONS. RESID FUEL HEAT CONTENT IS 6.287E06 499
BTU/BBL. 599

2211 199

FROM FOOTNOTE 2208, TANKERS LOSE ABOUT 0.11P OF THEIR CARGOES. 299
THUS PE IS 1-.0011, OR 0.9989. 399

2212 199

BOD LOADING FOR RESID IS ASSUMED TO BE STATISTICALLY SIMILAR TO 299
THAT OF CRUDE OIL. EMISSIONS BASED ON(2009,TABLE 5). 399

CONTROLLED FUEL	REGION
OIL	IMPORTED N.A. RESIDUAL F.O.

ROW	MNE-MON.	ACTIVITY PROCESS	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL BTU/10^{12}BTU	13 PARTIC-ULATES
			WATER POLLUTANTS (TONS/ 10^{12} BTU, EX COL 12)												
1	TRNSP	BRBD TRANSPORT													
2	TANKR	TANKER	0000	0000	0000	0000	0000	0000	0000	7.56+00 3 2314	7.56+00 3	0000	0000	0000	2.75-02 1 2204
3	PTERM	PRODUCT TERMINAL													
4	TNKST	STORAGE TANKS	0000	0000	0000	0000	0000	0000	0000	0000	0000	7.91-02 4 2312	0000	0.00+00 1 0007	8.00+00 1 0007
5															
6															
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 2000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
	AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						
THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/10^{12} BTU)	LAND (ACRE-YR/10^{12} BTU)	DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY (BTU/10^{12} BTU)	ROW
																1
0000	2.75-02 3 2200	2.17-01 3 2200	7.71-01 3 2200	1.90-02 3 2200	6.14-03 3 2200	3.15-03 3 2200	1.17+00	0000	0000	0000	0000	0000	2000	1.00+00 2 2315	0.00+00 2 2216	2
																3
0000	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0000	7.23-02 3 2209	0000	0000	0000	0002	1.00+00 2 2000	0.00+00 1 0+02	4
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TABLE 24. ENVIRONMENTAL IMPACTS AND EFFICIENCY FOR THE CONTROLLED SOUTH AMERICAN RESIDUAL REGION OF OIL SUPPLY

2314

BASED ON 159000 BBL/YR (EQUIVALENT TO 1.0E 12 BTU/YR FROM FOOTNOTE 2208) AND 6.04 BBL/TON FOR RESID (FOOTNOTE 2208), AND ON A CONTROLLED DISCHARGE LEVEL OF .0288 PC OF OIL TRANSPORTED (FOOTNOTE 2126), THERE IS 7.58 TON/YR OF RESID DISCHARGED TO WATER COURSES.

2315

BASED ON FOOTNOTE 2314 THE PRIMARY EFFICIENCY FOR DOUBLE BOTTOM TRANSPORT OF RESID IS 1.00-.000288 OR .9997.

V. NATURAL GAS SUPPLY

A. Introduction

All natural gas data are contained in Table 25. The table, as it appears, presents controlled and uncontrolled natural gas supply impacts. The footnotes following Table 25 are written for the uncontrolled national case. Use of the table for other situations is described in the following sections.

1. National--Controlled

The impacts and costs for the national controlled case are the same as for the uncontrolled case, since there are no regulations relating to the combustion of natural gas. With regard to LPG transported by diesel trucks, the 1975 standards permit emissions at levels above those currently indicated in the compilation of Air Pollutant Emission Factors (Reference 0002, page 3-7).

2. Domestic Onshore and Domestic Offshore--Controlled and Uncontrolled

The 1968 offshore production of natural gas was approximately four percent of the total U.S. production (Reference 0010,page 63, 108). Aside from production, the only activity for which impacts for offshore and onshore gas might differ is that of pipeline transportation. However, since most of the offshore gas is produced in the Gulf of Mexico adjacent to Texas and Louisiana, which together account for about 75 percent of the national onshore production, a local market for the offshore production is not identifiable. Because of the commingling and transport of offshore and onshore gas from this area through much of the national pipeline system, the allocation of pipeline mileage to offshore and onshore gas, as a basis for computing impacts, is infeasible, and the national average impacts are considered to be applicable for both offshore and onshore gas.

To obtain the ONSHORE region from Table 25, delete rows 2, 9, 12, 17, 18, and 19.

To obtain the OFFSHORE region from Table 25, delete rows 3, 9, 12, 17, 18, and 19.

3. Imported Canadian--Controlled and Uncontrolled

The 1971 imports of Canadian natural gas amounted to 9.04 (10^{11}) CF which was approximately four percent of the U.S. marketed production (Reference 0004, page 34, 35). Canadian gas is used in the states of Washington, Oregon, California, Idaho, Montana, Minnesota, and Vermont. Allocating the 1971 transmission and distribution pipeline mileages for these states (Reference 0004, page 52) on the basis of the Canadian gas fraction of the total gas inflow to each state (Reference 3005, page 22) gives 39,784 miles, which is approximately 4.6 percent of the national total. Since the estimated percentages of imported Canadian gas and of the related pipeline usage are nearly the same, the impacts for transmission and distributionn pipelines are about the same for Canadian imported natural gas and domestically produced natural gas.

To obtain the IMPORTED CANADIAN region from Table 25, delete rows 1 through 9, 12, 13, 17, 18, and 19. (Rows applicable are 10, 11, 14, 15, and 16.)

B. Impact Data Table and Footnotes

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	FUEL	REGION															
	NATURAL GAS	NATIONAL	WATER POLLUTANTS (TONS/10^{12} BTU, EX. COL. 12)														AIR POLLU
					DISSOLVED SOLIDS												
ROW	SEQUENCE	ACTIVITY PROCESS	ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (D4)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/10^{12} BTU)	PARTIC-ULATES	NO_x	SO_x
1	EXTRACT	EXTRACTION															
2	OFFSHORE	OFFSHORE	0000	0000	0000	0000	0000		0000	0.00+00 2 0007		0000	0000	0000	0000	0000	0000
3	ONSHORE	ONSHORE	0.00+00 2 3003	0.00+00 2 3003	0.00+00 2 3003	0.00+00 2 3003	0.00+00 2 3003	0.00+00 2	0.00+00 2 3003	0.00+00 2 0007	0.00+00 2	0000	0000	0000	0000	0000	0000
4	GATHER	GATHERING															
5	PIPELINE	PIPELINE	0000	0000	0000	0000	0000		0000	0000		0000	0000	0000	0.00+00 2 3001	2.65+00 3 3001	0.00+00 2 3001
6	TRUCK	PROCESSING															
7	NGLSEP	NGL SEPARATION	0000	0000	0000	0000	0000		0000	0.00+00 2 0007	0.00+00 2	0000	0000	7.70+00 4 3020	2.60+01 3 3027	1.00+00 3 3027	0.56+03 3 3027
8	HGREM	Hg2 REMOVAL	0000	0000	0000	0000	0000		0000	0000		0000	0000	8.10+00 3 3030	0.05+00 3 3030	2.00+01 3 3030	1.42+02 3 3030
9	LNG/L	LNG LIQUEFACTION	0000	0000	0000	0000	0000		0000	0000		0000	0000	3.03+11 3 3010	0.00+00 2 3010	3.54+02 3 3010	0.00+00 2 3010
10	TRANS	TRANSMISSION/DISTRIBUTION															
11	PIPELI	PIPELINE	0000	0000	0000	0000	0000		0000	0000		0000	0000	0000	0.00+00 2 3001	1.03+02 3 3001	0.16+01 2 3001
12	TANKER	LNG TANKER	0000	0000	0000	0000	0000		0000	2.12 01 4 3000	2.12 01 4	0.00+00 1 0007	0000	5.00+00 1 0007	3.15+02 4 3007	4.37 01 4 3007	2.56 01 4 3007
13	TRUCK	LPG TRUCKS	0000	0000	0000	0000	0000		0000	0000		0000	0000	0000	2.65 01 3 3002	0.01+00 3 3002	1.00 01 3 3002
14	STORAG	STORAGE															
15	UGRND	UNDERGROUND	0000	0000	0000	0000	0000		0000	0000		0000	0000	0000	0.00+00 2 3015	1.22+01 2 3015	0.00+00 2 3015
16	GASLD	GAS HOLDERS	0000	0000	0000	0000	0000		0000	0000		0000	0000	0000	0.00+00 2 3015	1.22+01 2 3015	0.00+00 2 3015
17	LNGTK	LNG TANK	0000	0000	0000	0000	0000		0000	0000		0000	0000	0000	0000	0000	0000
18	CONVT	CONVERSION															
19	LNGVP	LNG VAPORIZATION	0000	0000	0000	0000	0000		0000	0000		0000	0000	0.00+00 1 3021	1.47 01 3 3022	1.00+00 3 3022	0.00 03 3 3022
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NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.
SEE FOOTNOTE 3000 FOR MEASURE EQUIVALENTS OF 10^{12} BTU.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/10^{12} BTU)							SOLIDS TONS/ 10^{12}BTU	LAND (ACRE-YR/ 10^{12} BTU)	OCCUPATIONAL HEALTH			POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12}BTU	COST (DOLLARS/10^{12} BTU)			
...NITRO-...LATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL			DEATHS 10^{12} BTU	INJURIES 10^{12} BTU	MAN-DAYS LOST/10^{12}BTU				FIXED COST	OPERATING COST	TOTAL COST	ROW
0000	0000	0000	0000	0000	0000		0000	1.15-01 4 3010	0.00-00 0 3001	1.00-00 0 3001	1.00-02 0 3011	3010	0.00-01 2 3006	0.00+00 2 0007	2.18+04 3 3030	2.85+04 4 3040	5.04+04 2 3040	1
0000	0000	0000	0000	0000	0000		0000	6.15-01 4 3010	0.17-05 0 3001	1.57-03 0 3001	1.16-01 4 3011	3010	0.00-01 2 3006	0.00+00 2 0007	6.59+04 3 3030	4.50-03 4 3040	5.04+04 2 3040	2
																		3
0000 2 3001	2.89+00 3 3001	0.00+00 2 3001	7.77-02 3 3004	0.00+00 2 3001	0.00+00 2 3001	2.00+02 3	0000	2.12+01 3 3000	.07-08 4 3010	1.0+-03 4 3010	3.47-01 4 3010	3030	0.02-01 2 3006	0.00+00 2 0007	2.20+04 3046	0.41+03 4 3042	2.94+04 4	4
																		5
-01 3 3027	1.00+00 3 3027	0.50-03 3 3027	6.20-01 3 3027	0.30-03 3 3027	1.57-01 3 3027	2.00+00 3	0000	1.33-01 4 3020	0.1.-.5 4 3020	3.85-01 4 3020	1.57-02 4 3020	3030	0.16-01 2 3006	0.00+00 2 0007	5.58+04 3 3053	3.00+03 3 3053	6.28+04 2 3053	6
-03 3 3025	2.04-01 3 3025	1.62-03 3 3025	9.68-02 3 3025	0.45-04 3 3025	2.30-02 3 3025	4.47-01 3	0000	1.33-01 4 3020	2.10-.5 4 3020	1.00-03 4 3020	1.10-03 4 3020	3030	0.07-01 2 3055	0.00+00 2 0007	2.12+04 2 3052	3.30+03 3 3052	2.85+04 3	7
0000 2 3010	1.54-02 3 3010	0.00+00 2 3010	0.00+00 2 3010	0.00+00 2 3010	0.00+00 2 3010	3.70+00 3	0000	1.75-02 4 3010	[illegible]	[illegible]	[illegible]	3010	0.30-01 2 3056	0.00+00 2 0007	1.03+05 2 3048	8.85+04 2 3048	1.92-05 2	8
																		9
0000 2 3001	1.03-02 3 3001	0.00+00 2 3001	0.00+00 2 3001	0.00+00 2 3001	0.00+00 2 3001	1.03+02 3	0000	0.11+01 4 3010	1.00-05 4 3010	1.30-02 4 3010	1.24-01 4 3010	3030	0.71-01 2 3001	0.00+00 2 0007	1.69+05 1 3043	6.22+04 2 3041	2.31+05 3	10
-00 4 3007	4.37-01 4 3007	3.30-01 4 3007	1.56-02 4 3007	0.10-03 4 3007	4.35-03 4 3007	8.31-01 4	0000	4.90-02 3 3011	0000	0000	0-03	3030	0.66-01 3 3001	2.43-10 3 3007	1.14+05 3 3050	5.04+04 3 3050	1.44+05 3	11
-01 3 3002	6.05+00 3 3002	0.09-01 3 3002	0.00-01 3 3002	4.21+00 3 3002	1.13-01 3 3002	1.27+01 3	0000	1.22-02 4 3010	0000	0000	0000	3030	1.00+00 3 3056	5.21+00 3 3050	3054	3054	1.44+05 3 3054	12
																		13
0000 2 3015	1.22+01 3 3015	0.00+00 2 3015	0.00+00 2 3015	0.00+00 2 3015	0.00+00 2 3015	1.22+01 3	0000	1.75+00 4 3014	0000	0000	0000	3030	0.10-01 3 3010	0.00+00 1 0007	0.10+03 4 3045	6.30+03 2 3046	1.47+04 4	14
0000 2 3015	1.22+01 3 3015	0.00+00 2 3015	0.00+00 2 3015	0.00+00 2 3015	0.00+00 2 3015	1.22+01 3	0000	1.30-01 [illegible]	0000	0000	0000	3030	0.00-01 3 3010	0.00+00 1 0007	1.64+04 3 30474	02+02 3 3047	1.60+04 3	15
0000	0000	0000	0.00+00 2 0007	0000	0000	0.00+00 2	0000	7.04+00 3 3011	0000	0000	0000	3030	1.00+00 3 3000	2.01+00 3 3001	2.55+04 3 3051	8.03+03 3 3051	2.43+04 3	16
																		17
-04 3 3022	1.00+00 3 3022	0.00-03 3 3022	7.03-02 3 3022	1.00-01 3 3022	1.00-01 3 3022	1.57+00 3	0000	1.33-01 3 3011	0000	0000	0000	3030	0.00-01 2 3010	7.11+08 2 1050	1.08+03 2 3040	1.55-04 2 3040	1.66+04 2	18
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TABLE 25. ENVIRONMENTAL IMPACTS, EFFICIENCY AND COST FOR UNCONTROLLED AND CONTROLLED NATURAL GAS SUPPLY

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3000

ENTRIES IN THE TABLE ARE BASED ON AN ENERGY INPUT TO EACH PROCESS OF 1.0E12 BTU/YR. THE FOLLOWING TABLE GIVES DATA ON NATURAL GAS AND LPG USED IN THE COMPUTATIONS.

FUEL	NATURAL GAS	LPG
AVERAGE CALORIC CONTENT (0005,38)	1031 BTU/SCF	95500 BTU/GAL
AVERAGE SPEC.WT.(3002,2-10,5-11)	4.6E-2 LB/SCF	4.5 LB/GAL
VOLUME EQUIVALENT TO 1.0E12 BTU	9.7E8 SCF	1.048E7 GAL

NOTE - SCF = STANDARD CUBIC FOOT (60 DEG F, 14.73 PSIA)

3001

BASED ON THE USE OF NATURAL GAS AS PIPELINE FUEL. THE 1970 VALUES FOR GAS USED AS PIPELINE FUEL AND DELIVERED GAS WERE 7.22E11, 1.902E13 CF, RESPECTIVELY (0025,758). PIPELINE FUEL IS 3.67P OF THE SUM OF THESE. THIS IS ALLOCATED TO FIELD/GATHERING AND TRANSMISSION PIPELINE MILEAGES, WHICH WERE 6.65E4, 2.569E5 MI, RESPECTIVELY, IN 1971 (0004,51). THE USE OF GAS ENGINES TO DRIVE THE COMPRESSORS IS ASSUMED, THE EMISSION FACTOR FOR NOX BEING 7300 LB/MMCF (0002,1-9). ALLOCATION TO 1.0E12 BTU/YR GIVES NOX VALUES OF 2.65 T/1.0E12 BTU FOR FIELD/GATHERING,AND 103 T/1.0E12 BTU FOR TRANSMISSION PIPELINES. IF GAS TURBINES ARE USED THE NOX EMISSION FACTOR IS 200 LB/MMCF (0002,1-9), AND THE FOLLOWING NOX VALUES SHOULD BE SUBSTITUTED - FIELD/GATHERING, 0.73 T/1.0E12 BTU, AND TRANSMISSION, 2.82 T/ 1.0E12 BTU. THE DISTRIBUTION MILEAGE IS NOT INCLUDED IN THE COMPUTATIONS BECAUSE COMPRESSORS ARE NOT NORMALLY USED ON DISTRIBUTION MAINS.

3002

BASED ON USE OF DIESEL TRACTOR-TRAILER WITH 9100 GAL PAYLOAD, PAYLOAD AT 62P OF GROSS WEIGHT, 150 GROSS TMI/GAL OF DIESEL FUEL, TRIP DISTANCE OF 100 MI LOADED AND 100 MI EMPTY,AND EMISSION FACTORS (0002,3-7). THE FUEL CONSUMPTION IS ESTIMATED TO BE 3.76E4 GAL/1.0E12 BTU FOR THE 200 MI ROUND TRIP.

3003

POLLUTION OF FRESH WATER BY BRINES RELEASED FROM NATURAL GAS WELLS IS ASSUMED TO BE NEGLIGIBLE BECAUSE OF ENFORCEMENT OF REGULATIONS FOR CONTROL OF POLLUTION BY STATE CONSERVATION COMMISSIONS (0003,113/149).

3004

BASED ON 1971 STATISTICS OF 24.1E12 CF GROSS PRODUCTION, 0.3E12 CF LOSSES AND WASTE IN FIELD AND 2.30E12 CF FOR FIELD USE 0004,29).

3005

BASED ON SIMULATED TYPICAL WELL PRODUCTIVITY FOR 25 YEARS PRODUCTION (3008,120-122).

3006

BASED ON 1971 LEASE AND PLANT FUEL CONSUMPTION OF 1.40E12 CF FOR AN INPUT OF 2.114E13 CF (2.205E13 TOTAL LESS 9.06E11 PHYSICAL LOSS) (0025,758).

3007

BASED ON AN LNG TANKER WITH A CAPACITY OF 1.0E12 BTU, WHICH IS EQUIVALENT TO 294,000 BBL LNG. THE TANKER IS ASSUMED TO BE A STEAMSHIP AND TO OPERATE WITHIN THE COASTAL WATERS OF THE U.S. FOR A DISTANCE OF 100 N MI/ROUND TRIP. TIME IN BERTH IN A U.S. PORT IS ASSUMED TO AVERAGE 2 DAYS/ROUND TRIP. DIESEL TUGBOAT USE IN U.S. PORTS IS ASSUMED TO AVERAGE 10 N MI/ROUND TRIP. EMISSION FACTORS USED ARE THOSE FOR STEAMSHIPS AND MOTORSHIPS

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FTN. 3008-3010

(0002,3-11). NO VESSEL SIZES ARE SPECIFIED FOR THESE FACTORS. THE SULFUR CONTENT OF THE FUEL IS ASSUMED TO BE 0.5P, AND NO ADJUSTMENT OF FACTORS HAS BEEN MADE FOR USE OF BOIL-OFF GAS AS PART OF THE TANKER FUEL. VALUES IN THE TABLE BELOW ARE IN TONS/1.0E12 BTU FOR 100 MI TRAVEL IN COASTAL WATERS AND 2 DAYS IN PORT.

	LNG TANKER		TUGBOATS	TOTALS
	COASTAL	IN-BERTH		
PARTICULATES	2.0E-2	1.5E-3	1.0E-1	3.15E-2
NOX	2.3E-1	2.0E-1	7.0E-3	4.37E-1
SOX	1.8E-1	1.52E-1	3.7E-3	3.36E-1
HC	1.0E-2	9.0E-3	4.5E-3	1.54E-2
CO	1.0E-4	8.0E-5	6.0E-3	6.18E-3
ALDEHYDES,ETC	2.0E-3	2.0E-3	3.5E-4	4.35E-3

3008

BASED ON ESTIMATE OF DISCHARGE OF 12 GAL OIL PER DAY DUE TO BILGE PUMPING, LEAKS, AND BUNKERING OPERATIONS. VESSEL IS ASSUMED TO BE IN BERTH AND IN U.S. COASTAL WATERS A TOTAL OF 5 DAYS/TRIP. SEE FOOTNOTE 3007 FOR VESSEL DATA. SPECIFIC GRAVITY OF OIL DISCHARGE IS ASSUMED TO BE 0.85.

3009

BASED ON 1971 FIELD AND GATHERING PIPELINE MILEAGE, 6.65E4 MI (0004,51) AND 1971 NET PRODUCTION, 2.279E13 CF (0004,29). THE PIPELINE RIGHT-OF-WAY VARIES FROM 50 TO 75 FT (2002,14). AN AVERAGE OF 62.5 FT IS USED. COMPRESSION STATIONS ARE ASSUMED TO BE LOCATED 187 MI APART (3002,8-50) AND OCCUPY 25 AC EACH (3002,8-96). THE ALLOCATION FRACTION FOR 1.0E12 BTU/YR IS 4.26E-5, GIVING 21.4 AC-YR/1.0E12 BTU FOR THE PIPELINE AND 0.38 AC-YR/1.0E12 BTU FOR THE COMPRESSOR STATIONS.

CALCULATIONS WERE ALSO MADE USING DATA FROM A RECENT FPC DOCKET FOR THE MICHIGAN-WISCONSIN PIPELINE CO. (3007). LAND REQUIREMENTS FOR COMPRESSOR STATIONS (4000 HP) ARE GIVEN AS 10 ACRES WITH STATIONS AN AVERAGE OF 75 MILES APART. USING THE GATHERING AND TRANSMISSION PIPELINE MILEAGE FROM (0004, 51), LAND IMPACT FOR COMPRESSOR STATIONS WAS CALCULATED. FOR GATHERING PIPELINES, THIS AMOUNTS TO 0.38 AC-YR/1.0E12 BTU. FOR TRANSMISSION PIPELINES, LAND IMPACT AMOUNTS TO 1.49 AC-YR/1.0E12 BTU. THE IMPACTS ARE IDENTICAL TO THOSE DERIVED USING 25 ACRE STATIONS LOCATED 187 MILES APART.

3010

BASED ON 1971 TRANSMISSION AND DISTRIBUTION PIPELINE MILEAGES, 2.569E5 AND 6.113E5 MI,RESPECTIVELY,(0004,51), AND 1971 MARKETED PRODUCTION, 2.249E13 CF (0004,29). THE PIPELINE RIGHT OF-WAY VARIES FROM 50 TO 75 FT (2002,14). AN AVERAGE VALUE OF 62.5 FT IS ASSUMED FOR TRANSMISSION PIPELINES. COMPRESSOR STATIONS ARE ASSUMED TO BE LOCATED 187 MI APART (3002,8-50) ON TRANSMISSION PIPELINES AND OCCUPY 25 AC EACH (3002,8-96). NO COMPRESSOR STATIONS ARE REQUIRED ON DISTRIBUTION MAINS. SINCE DISTRIBUTION MAINS ARE TO A LARGE EXTENT UNDER URBAN STREETS THE RIGHT-OF-WAY IMPACT IS SMALL. A LAND IMPACT OF 25 AC/100 MI IS ASSUMED FOR DISTRIBUTION SYSTEMS FOR CONTROL EQUIPMENT. THE ALLOCATION FRACTION FOR 1.0E12 BTU/YR IS 4.31E-5, GIVING 84.0 AC-YR/1.0E12 BTU FOR TRANSMISSION PIPELINES, 1.47 AC-YR/ 1.0E12 BTU FOR COMPRESSOR STATIONS, AND 6.6 AC-YR/1.0E12 BTU

FOR DISTRIBUTION MAINS. FTN. 3011-3013 1699
CALCULATIONS WERE ALSO MADE USING DATA FROM A RECENT FPC 1799
DOCKET FOR THE MICHIGAN-WISCONSIN PIPELINE CO. (3007). LAND 1899
REQUIREMENTS FOR COMPRESSOR STATIONS (4000 HP) ARE GIVEN AS 1999
10 ACRES WITH STATIONS AN AVERAGE OF 75 MILES APART. USING 2099
THE GATHERING AND TRANSMISSION PIPELINE MILEAGE FROM (0004, 2199
51), LAND IMPACT FOR COMPRESSOR STATIONS WAS CALCULATED. FOR 2299
GATHERING PIPELINES, THIS AMOUNTS TO 0.38 AC-YR/1.0E12 BTU. 2399
FOR TRANSMISSION PIPELINES, LAND IMPACT AMOUNTS TO 1.49 AC- 2499
YR/1.0E12 BTU. THE IMPACTS ARE IDENTICAL TO THOSE DERIVED 2599
USING 25 ACRE STATIONS LOCATED 187 MILES APART. 2699

3011 199
FROM (3010,58), COLUMBIA GAS COMPANY'S 1.0E9 SCFD RECEIVING TER- 299
MINAL AT COVE POINT, MD. WILL OCCUPY A 1000 ACRE SITE INCLUDING 399
FUEL STORAGE DEPOT, DOCK AND PORT FACILITIES AND VAPORIZATION 499
SYSTEM. THIS CORRESPONDS TO 2.66 AC-YR/1.0E12 BTU. ALLOCATION 599
TO STORAGE, VAPORIZATION AND PORT IS MADE ON THE ASSUMPTION 699
THAT ACREAGE IS APPROXIMATELY PROPORTIONAL TO THE INVESTMENT 799
VALUES GIVEN IN (3000,3-50). 899

3012 199
BASED ON THE 1969 VOLUME OF INTERCITY HIGHWAY FREIGHT TRAFFIC, 299
3.963E11 TMI (0010,267), AND THE 1969 SHIPMENTS OF LPG, 399
3.33E8 BBL (0001,755) EQUIVALENT TO 3.15E07 TONS. THE FRAC- 499
TION TRANSPORTED BY TRUCK IS ASSUMED TO BE 16.7PC, BASED ON 599
1967 DATA (3006,39). DISTANCE FOR LADEN TRIP IS ASSUMED TO 699
BE 100 MI, GIVING 5.26E08 TMI/YR OF LPG OR 0.13 PC OF TOTAL 799
VOLUME OF INTERCITY HIGHWAY FREIGHT. THE AMOUNT OF LPG 899
EQUIVALENT TO 1.0E12 BTU/YR IS 2.36E04 TONS OR 2.36E06 TMI/YR, 999
EQUIVALENT TO 0.45PC OF LPG TRUCK SHIPMENTS AND THE HIGHWAY 1099
RIGHT-OF-WAY IN THE 48 STATES, 2.1E7 AC (SEE FOOTNOTE 7026), 1199
GIVES 122 AC-YR/1.0E12 BTU. 1299

3013 199
BASED ON 1963 DATA, 102966 PRODUCING GAS WELLS (0010,54), IN- 299
CLUDING 387 OFFSHORE WELLS (0010,63), TOTAL PRODUCTION OF 399
1.261E13 CF (0010,108), INCLUDING 4.887E11 CF FROM OFFSHORE 499
WELLS (0010,63). ON THIS BASIS AND CONSIDERING 30 P RECOVERY 599
OF GAS-IN-PLACE, AV CAPACITIES PER WELL ARE 3.94E8 CF ONSHORE 699
AND 4.21E9 CF OFFSHORE. ASSUMING A LAND REQUIREMENT OF 1/4 AC/ 799
WELL ONSHORE AND 1/2 AC/WELL OFFSHORE, THE IMPACTS ARE .615 899
AC-YR/1.0E12 BTU IN ONSHORE, AND .115 AC-YR/1.0E12 BTU OFF- 999
SHORE. IF GAS PRODUCTION FROM OIL WELLS IS UNDER CONSIDERA- 1099
TION, THE LAND IMPACTS SHOULD INCLUDE 2.30 AC-YR/1.0E12 BTU 1199
FOR ONSHORE WELLS AND .278 AC-YR/1.0E12 BTU FOR OFFSHORE 1299
WELLS. THESE VALUES ARE BASED ON 1963 DATA, 588777 OIL WELLS 1399
(0010,45), INCLUDING 2321 OFFSHORE OIL WELLS (0010,63), 1499
TOTAL GAS PRODUCTION FROM OIL WELLS OF 4.367E12 CF (0010,108), 1599
INCLUDING 2.79E11 CF FROM OFFSHORE OIL WELLS (0010, 63), 1699
TOTAL OIL PRODUCTION OF 2.753E9 BBL (0010,70) INCLUDING 1.747 1799
E8 BBL FROM OFFSHORE OIL WELLS (0010,63). ON THIS BASIS, AND 1899
CONSIDERING 30P RECOVERY FOR BOTH OIL AND GAS, AV CAPACITIES 1999
PER OIL WELL ARE 2.32E7 CF GAS AND 1.47E4 BBL OF OIL FOR ON- 2099
SHORE WELLS, 4.20E8 CF GAS AND 2.50E5 BBL OIL FOR OFFSHORE 2199
WELLS. ON THIS BASIS, 41.8 ONSHORE, OR 2.42 OFFSHORE OIL 2299
WELLS ARE REQUIRED FOR 1.0E12 BTU IN/YR OF GAS. THE ALLOCA- 2399
TION OF ACREAGE TO GAS IS BASED ON THE GAS FRACTION OF THE 2499
TOTAL CAPACITY/WELL, EXPRESSED IN BTU EQUIVALENTS. USING 2599
5.62E6 BTU/BBL OIL (0005,38) THE GAS FRACTIONS ARE 0.22 FOR 2699
ONSHORE OIL WELLS AND 0.23 FOR OFFSHORE OIL WELLS. AT 1/4 2799
AC/WELL ONSHORE AND 1/2 AC/WELL OFFSHORE THE IMPACTS GIVEN 2899
ABOVE ARE OBTAINED. 2999

FTN. 3014-3023

3014

BASED ON THE 1971 NO. OF UNDERGROUND STORAGE POOLS (DEPLETED FIELDS, AQUIFERS, CAVERNS), 333 (0004,58), AND THE 1971 INPUT TO STORAGE, 1.85E12 SCF. ON THIS BASIS AN INPUT OF 1.0E12 BTU/YR REQUIRES 0.175 POOL. THE ACREAGE ASSOCIATED WITH EACH POOL IS ASSUMED TO BE THAT REQUIRED FOR A COMPRESSOR STATION AND RELATED EQUIPMENT, 10 AC PER POOL (3001,5).

3015

BASED ON THE RATIO OF 1971 STORAGE POOL COMPRESSOR HP, 1.042E6 (0004,62), TO 1971 TOTAL PIPELINE COMPRESSOR HP, 1.076E7 (0004,50), AND EMISSIONS FOR PIPELINES (SEE FOOTNOTE 3001). THE SAME BASIS IS USED FOR HIGH PRESSURE GAS HOLDERS.

3016

BASED ON THE ASSUMPTION THAT THE USE OF GAS AS FUEL FOR STORAGE COMPRESSORS IS PROPORTIONAL TO THE USE OF GAS FOR PIPELINE COMPRESSORS. USING THE COMPRESSOR HP RATIO (FOOTNOTE 3015), AND THE PIPELINE FUEL USE (FOOTNOTE 3001), THE STORAGE FUEL USE IS ESTIMATED AT 0.36P.

3018

ASSUMED EQUAL TO THE LAND REQUIREMENT FOR VAPORIZATION OF LNG (SEE FOOTNOTE 3011).

3019

BASED ON 17P OF INPUT USED AS FUEL FOR THE LIQUEFACTION PLANT (3000,3-43) AND EMISSION FACTOR FOR NOX OF 4300 LB/MMCF AND ZERO FOR THE OTHER POLLUTANTS (0002,1-9).A GAS ENGINE DRIVE IS ASSUMED. EMISSIONS WOULD THUS BE 3.54E02 TONS NOX/1.0E12 BTU FOR A GAS TURBINE DRIVE, THE EMISSION FACTOR FOR NOX WOULD BE 200 LB/MMCF (0002,1-9),GIVING 16.5 TONS NOX/1.0E12 BTU.

3020

THE THEORETICAL COOLING REQUIRED TO CONVERT 1 LB OF NATURAL GAS (ASSUMED TO BE 100P METHANE) AT 100 DEG F AND 100 PSIA TO A LIQUID AT ATMOSPHIC PRESSURE AND -258 DEG F IS 398 BTU (3000, 2-172). THIS CORRESPONDS TO A DISCHARGE TO COOLING WATER OF 1.80E10 BTU/1.0E12 BTU. ADDITIONALLY, PART OF THE ENERGY USED TO DRIVE THE PROCESS IS ALSO DISCHARGED TO COOLING WATER. ASSUMING THAT 17P OF THE INPUT GAS IS USED AS FUEL (3008, 424) AND THAT 50 PC OF THE ENERGY CONTENT IS DISCHARGED TO COOLING WATER, A DISCHARGE OF 8.50E10 BTU/1.0E12 BTU RESULTS. IF A COOLING TOWER IS USED A VALUE OF ZERO SHOULD BE SUBSTITUTED.

3021

VAPORIZATION BY COMBUSTION OF GAS IS ASSUMED. SOME DESIGNS USE WATER AS A SOURCE OF HEAT. IN SUCH CASES A NEGATIVE THERMAL IMPACT WOULD RESULT, THE MAGNITUDE BEING ABOUT -1.80E10 BTU/1.0E12 BTU (SEE FOOTNOTE 3020).

3022

BASED ON USE OF 2P OF LNG INPUT AS FUEL IN VAPORIZER (3000,2-252), AND EMISSION FACTORS FOR NATURAL GAS COMBUSTION IN COMMERCIAL HEATERS (0002,1-9).

3023

HIGH PRESSURE STORAGE TANKS ARE ASSUMED, REQUIRING 1.25 AC/MMCF OF GAS STORAGE CAPACITY (3002,10-16). THE STORAGE CAPACITY IS ASSUMED TO BE EQUAL TO 10P OF DAILY PIPELINE FLOW. THE FLOW FOR 1.0E12 BTU/YR IS 2.64 MMCFD. THUS, THE LAND REQUIREMENT IS 0.33 AC-YR/1.0E12 BTU.

3024

BASED ON THE AQUEOUS AMINE PROCESS, WHICH IS THE MOST COMMONLY USED PROCESS FOR H2S REMOVAL (3002,4-86). THE VALUE FOR 1.0E12 BTU/YR IS BASED ON DATA FOR TREATMENT OF 60 MMCFD WITH 100 GRAINS H2S PER 100 CF OF GAS (3002,4-88). THE FLOW THROUGH THE HEAT EXCHANGER IS 80 GPM OF 20P MONOETHANOLAMINE SOLUTION AND THE TEMPERATURE CHANGE IS 55 DEG F. THE SPECIFIC GRAVITY OF MEA IS 1.022 (0028,3-22). THE SPECIFIC HEAT OF THE 20P MEA SOLUTION IS ESTIMATED TO BE 0.95 BTU/LB-DEG F. IF A COOLING TOWER IS USED A VALUE OF ZERO SHOULD BE SUBSTITUTED.

3025

THE H2S REMOVED FROM THE NATURAL GAS IS ASSUMED TO BE CONVERTED TO ELEMENTAL SULFUR, USING, FOR EXAMPLE, THE CLAUS-CHANCE PROCESS AS MODIFIED BY MATHIESON CHEMICAL CO. THE EXIT GASES FROM THE PROCESS, VENTED TO THE ATMOSPHERE, ARE PRIMARILY NITROGEN, CARBON DIOXIDE, AND WATER VAPOR (3000,2-71). THE FUEL FOR THE PROCESS IS THE ACID WASTE GAS FROM THE AMINE PROCESS (SEE FOOTNOTE 3024). THE POLLUTANT VALUES FOR 1.0E12 BTU/YR ASSUME NATURAL GAS AS FUEL TO GENERATE STEAM FOR THE AMINE PROCESS.

ON THE BASIS OF 8250 LB/HR OF 40 PSIA STEAM FOR A 60 MMCFD PLANT (3.3 LBS STEAM/MCF) (3000,2-50) AND 75P COMBUSTION EFFICIENCY, THE FUEL REQUIRED IS 0.29 MMCFD. THE EMISSION FACTORS ARE FOR INDUSTRIAL PROCESS BOILERS (0002,1-9). IF EXHAUST STEAM FROM A POWER PLANT IS USED, THE AIR POLLUTANT VALUES FOR THE PROCESS ARE ZERO.

3026

BASED ON AN ASSUMED VALUE OF 5 AC FOR A 100 MMCFD PLANT.

3027

BASED ON 3.1P OF GAS PROCESSED USED AS PLANT FUEL AND 0.1P FLARED (0025,759). THE EMISSION FACTORS ARE THOSE FOR INDUSTRIAL PROCESS BOILERS (0002,1-9).

3028

BASED ON AN ASSUMED THERMAL DISCHARGE EQUAL TO 25P OF THE ENERGY CONTENT OF THE GAS USED AS PLANT FUEL (SEE FOOTNOTE 3027). IF A COOLING TOWER IS USED A VALUE OF ZERO SHOULD BE SUBSTITUTED.

3029

BASED ON 1971 DATA FOR GAS PIPELINES (0035,5), 346 DISABLING WORK INJURIES, 8086 MAN-DAYS LOST, 1 DEATH. AN APPROXIMATE ALLOCATION IS MADE TO 1.0E12 BTU/YR ON THE BASIS OF THE 1971 MARKETED PRODUCTION, 2.249E13 CF (0004,56). ON THIS BASIS, THE ALLOCATION FRACTION IS 4.31E-5. ALLOCATION TO FIELD/GATHERING AND TRANSMISSION/DISTRIBUTION PIPELINES IS BASED ON MILEAGES (FOOTNOTES 3009,3010).

3030

BASED ON 1971 DATA FOR NATURAL GAS PROCESSING (0035,4), 89 DISABLING WORK INJURIES, 2366 MAN-DAYS LOST, 1 DEATH. AN APPROXIMATE ALLOCATION TO 1.0E12 BTU/YR IS MADE ON THE OF THE 1971 MARKETED PRODUCTION, 2.24E13 CF (0004,56). ON THIS BASIS, THE ALLOCATION FRACTION IS 4.31E-5. A FURTHER ALLOCATION OF 95P TO NGL SEPARATION AND 5P TO H2S SEPARATION IS ASSUMED.

3031

BASED ON 1971 DATA FOR PRODUCTION OF OIL AND GAS (0035,4), 595 DISABLING WORK INJURIES 20235 MAN-DAYS LOST, 13 DEATHS. ALLOCATION TO GAS AND OIL PRODUCTION IS MADE ON THE BASIS OF 1971 DATA FOR PRODUCTION OF MINERAL ENERGY (0004,20), UNPROCESSED NATURAL GAS 2.487E16 BTU, CRUDE PETROLEUM 1.956E16 BTU. ON THIS BASIS THE ALLOCATION FRACTION FOR GAS IS 0.56. THE ALLOCATION TO 1.0E12 BTU/YR IS MADE ON THE BASIS OF THE 1971 GAS PRODUCTION GIVEN ABOVE. ON THIS BASIS, THE ALLOCATION FRACTION IS 4.02E-5. ALLOCATION TO ONSHORE AND OFFSHORE IS MADE ON THE BASIS OF 1966 PRODUCTION OF UNPROCESSED NATURAL GAS, 1.898E16 BTU (0004,20), 1966 OFFSHORE GAS PRODUCTION IN GULF OF MEXICO 1.355E12 CF (2000,29), 1967 OFFSHORE GAS PRODUCTION FOR ALASKA AND CALIFORNIA 1.0E11 CF (2000,47). ON THIS BASIS, THE ALLOCATION FRACTIONS ARE 0.079 OFFSHORE, 0.921 ONSHORE. A 30P RECOVERY FACTOR IS APPLIED IN ORDER TO SHOW TABLE ENTRIES IN TERMS OF BTU EQUIVALENT IN.

3032

FIRE, EXPLOSION, EARTHQUAKE, HURRICANE, LARGE VESSEL COLLIDING WITH OFFSHORE PLATFORM, OR SOME COMBINATION OF THESE, AFFECTING PERSONNEL, PLATFORM AND ADJACENT VESSELS.

3033

FIRE, EXPLOSION, EARTHQUAKE, TORNADO, OR COMBINATIONS OF THESE, AFFECTING PRODUCTION PERSONNEL AND EQUIPMENT.

3034

DAMAGE TO PIPELINE CAUSED BY EXCAVATION EQUIPMENT OR EARTHQUAKE, RESULTING IN FIRE AND/OR EXPLOSION AFFECTING PERSONS AND PROPERTY IN VICINITY.

3035

FIRE, EXPLOSION, EARTHQUAKE, TORNADO, OR COMBINATION OF THESE, AFFECTING PLANT PERSONNEL AND EQUIPMENT.

3036

COLLISION OF TANKER WITH OTHER VESSEL OR STRUCTURE, RESULTING IN FIRE AND/OR EXPLOSION, AFFECTING CREW(S) AND VESSEL(S).

3037

COLLISION OF LPG TRUCK WITH OTHER VEHICLE OR STATIONARY OBJECT, RESULTING IN FIRE AND/OR EXPLOSION, AFFECTING PERSONS AND PROPERTY IN VICINITY.

3038

REMOTE POSSIBILITY OF FIRE DUE TO RELEASE OF GAS BY EARTHQUAKE.

3039

BASED ON 8.9 ONSHORE OR 0.77 OFFSHORE GAS WELL FOR PRODUCTION OF GAS EQUIVALENT TO 1.0E12 BTU/YR (SEE FOOTNOTE 3013). IN 1970 A TOTAL OF 3844 GAS WELLS WAS BROUGHT INTO PRODUCTION AT A TOTAL COST OF $6.176E8, INCLUDING 193 OFFSHORE WELLS AT A COST OF $1.389E8 (0004,45). ESCALATING TO 1972 DOLLARS USING CONSTRUCTION COST RATIO OF 1807/1380, AND USING 10P FIXED CHARGE RATE GIVES THE FIXED COSTS. IF GAS PRODUCTION FROM OIL WELLS IS UNDER CONSIDERATION 142 ONSHORE OR 8.1 OFFSHORE OIL WELLS ARE REQUIRED FOR PRODUCTION OF GAS EQUIVALENT TO 1.0E12 BTU/YR (SEE FOOTNOTE 3013). IN 1970 A TOTAL OF 12547 OIL WELLS WAS BROUGHT INTO PRODUCTION AT A TOTAL COST OF $1.088E9, INCLUDING 533 OFFSHORE WELLS AT A COST OF $2.82E8 (0004,45). ON THIS BASIS THE AV COST PER OIL WELL IS $6.73E4 FOR ONSHORE

AND $5.30E5 FOR OFFSHORE. ESCALATING AS ABOVE, USING 10P FCR, AND USING ALLOCATIONS TO GAS PRODUCTION OF 0.22 FOR ONSHORE AND 0.23 FOR OFFSHORE (SEET FOOTNOTE 3013) THE FIXED COSTS FOR PRODUCTION OF THE GAS EQUIVALENT OF 1.0E12 BTU/YR FROM OIL WELLS ARE $2.75E5 FOR ONSHORE AND $1.30E5 FOR OFF-SHORE. A 30P RECOVERY FACTOR IS APPLIED IN ORDER TO SHOW TABLE ENTRIES IN TERMS OF BTU EQUIVALENT IN.

3040

BASED ON THE 1971 AV WELLHEAD PRICE, $0.182/MCF (0004,26). ES-CALATED TO 1972 DOLLARS BY A FACTOR OF 1.064 (0004,26), GIVING $1.87E5/1.0E12 BTU. TAKING 90P OF THIS TO ALLOW FOR AN ASSUMED 10P PROFIT GIVES $1.68E5/1.0E12 BTU. THE OPERATING COST IF OBTAINED BY SUBTRACTING FIXED COST (FOOTNOTE 3039). A 30P RECOVERY FACTOR IS APPLIED IN ORDER TO SHOW TABLE ENTRIES IN TERMS OF BTU EQUIVALENT IN.

3041

BASED ON SUM OF TOTAL OPERATION AND MAINTENANCE EXPENSES FOR TRANSMISSION, $5.49E8, AND DISTRIBUTION, $8.12E8, FOR 1971, (0004,134). ALLOCATION TO 1.0E12 BTU ON BASIS OF 1971 MARKETED PRODUCTION, 2.249E13 CF (0004,56), GIVES $5.87E4. ASSUMING AN ESCALATION FACTOR OF 1.06 GIVES $6.22E4 IN 1972 DOLLARS.

3042

THE OPERATING AND MAINTENANCE EXPENSE FOR FIELD AND GATHERING LINES ARE ASSUMED TO BE PROPORTIONAL TO THOSE FOR TRANSMISSION LINES ON A MILEAGE BASIS. THE 1971 RATIO OF FIELD AND GATHER-ING MILEAGE TO TRANSMISSION MILEAGE IS 6.65E4/2.569E5 = 0.258 (0004,51). THE TRANSMISSION OPERATING AND MAINTENANCE EXPENSES FOR 1971 ARE $5.49E8 (0004,134). USING THE MILEAGE RATIO AND ALLOCATING TO 1.0E12 BTU ON THE BASIS OF 1971 NET PRODUCTION, 2.279E13 CF (0004,29), GIVES $6.05E3. ASSUMING AN ESCALATION FACTOR OF 1.06 GIVES $6.41E3 IN 1972 DOLLARS.

3043

BASED ON THE SUM OF THE TRANSMISSION AND DISTRIBUTION COMPONENTS OF GAS UTILITY INDUSTRY PLANT FOR 1971, $1.828E10 AND $1.576 E10,RESPECTIVELY (0004,150). ESCALATING TO 1972 DOLLARS USING CONSTRUCTION COST INDEX RATIO OF 1807/1570, AND USING 10P FIX-ED CHARGE RATE GIVES A FIXED COST OF $ 3.92E9/YR. ALLOCATING THIS TO 1.0E12 BTU/YR ON THE BASIS OF 1971 MARKETED PRODUCTION 2.249E13 CF (0004,56) GIVES $1.69E5/1.0E12 BTU.

3044

THE CAPITAL COST FOR FIELD AND GATHERING LINES IS ASSUMED TO BE PROPORTIONAL TO THAT FOR TRANSMISSION ON A MILEAGE BASIS. THE 1971 RATIO OF FIELD AND GATHERING MILEAGE TO TRANSMISSION MILEAGE IS 6.65E4/2.569E5 = 0.258 (0004,51). THE TRANSMISSION COMPONENT OF GAS UTILIY INDUSTRY FOR 1971 IS $1.828E10. ESCAL-ATING TO 1972 DOLLARS USING CONSTRUCTION COST RATIO OF 1807/ 1570, USING 10P FIXED CHARGE RATE, AND MULTIPLYING BY 0.258 GIVES A FIXED COST OF $5.42E8/YR. ALLOCATING TO 1.0E12 BTU/YR ON THE BASIS OF 1971 NET PRODUCTION, 2.279E13 CF (0004,29) GIVES $2.30E4/1.0E12 BTU

3045

BASED ON THE UNDERGROUND STORAGE COMPONENT OF GAS UTILITY INDUSTRY PLANT FOR 1971, $1.883E9 (0004,150). ESCALATING TO 1972 DOLLARS USING CONSTRUCTION COST INDEX RATIO OF 1807/1570, AND USING 10P FIXED CHARGE RATE GIVES A FIXED COST OF $2.17E8/YR. ALLOCATING THIS TO 1.0E12 BTU/YR ON THE BASIS OF 1971 MARKETED PRODUCTION, 2.249E13 CF (0004,56) GIVES $9.35E3/1.0E12 BTU.

3046

BASED ON THE 1971 OPERATING AND MAINTENANCE COST FOR STORAGE IN TOTAL INDUSTRY, $1.34E8 (0004,134). THIS IS ALLOCATED TO 1.0E 12 BTU ON THE BASIS OF 1971 MARKETED PRODUCTION, 2.249E13 CF (0004,56). ASSUMING AN ESCALATION FACTOR OF 1.06 GIVES $5.3E3 IN 1972 DOLLARS.

3047

HIGH PRESSURE STORAGE TANKS ARE ASSUMED, WITH STORAGE CAPACITY EQUAL TO 10PC OF DAILY PIPELINE FLOW. ON THIS BASIS, A CAPACITY OF 2.66E05 CF IS REQUIRED FOR 1.0E12 BTU/YR. THE COST FOR A CYLINDRICAL TANK OF THIS CAPACITY WAS $6.0E04 IN 1955 (3002,10-15). ESCALATING TO 1972 DOLLARS BY USING CONSTRUCTION COST INDEX RATIO 1807/660, AND USING 10P FIXED CHARGE RATE GIVES A FIXED COST OF $1.64E04/1.0E12 BTU. THE 1955 OPERATING AND MAINTENANCE COST WAS $172/YR (3002,10-15). ESCALATING THIS TO 1972 DOLLARS, USING THE NELSON LABOR INDEX RATIO 546/191, GIVES $492/1.0E12 BTU.

3048

A MODIFIED CASCADE CYCLE IS ASSUMED. THE 1970 GULF COAST BASIS CAPITAL COST FOR A 500 MMSCFD (OUTPUT) LIQUEFACTION PLANT IS ESTIMATED AT $1.6E08 (3008,371). ESCALATING TO 1972 DOLLARS USING THE CONSTRUCTION COST INDEX 1807/1380, AND USING A 10PC FIXED CHARGE RATE GIVES A FIXED COST OF $2.09E07. WITH SOURCE GAS AT PIPELINE QUALITY AND 750 PSIA, 17PC OF THE INLET GAS QUANTITY IS ASSUMED FOR PRETREATMENT AND LNG PROCESSING (3008, 424). THUS, INPUT IS TAKEN AS 1.2 TIMES OUTPUT. THE COST OF MARINE FACILITIES DEVELOPMENT IS GIVEN AS $20 x 10^6 BASED ON CONSTRUCTION IN 1976-1977 (3008,427). THOUGH THE COST WILL BE ALLOCATED TO 1.0E12 BTU/YR HERE, IT SHOULD BE NOTED THAT MARINE FACILITIES ARE NOT NEEDED IN MULTIPLES AS PLANT SIZE INCREASES (3008,371). ALLOCATION OF FIXED COST TO AN INPUT OF 1.0E12 BTU/YR IS $9.36E04/1.0E12 BTU. ALLOCATION OF MARINE FACILITIES COST TO 1.0E12 BTU/YR IS $8.96E03 AT A 10PC FIXED CHARGE RATE. THUS, TOTAL CAPITAL COST IS $1.03E05/1.0E 12 BTU. FROM (3008,372), THE ANNUAL 1970 GULF COAST BASIS OPERATING COST FOR A 500 MMSCFD OUTPUT LIQUEFACTION PLANT IS $6.5E06 EXCLUDING FUELS AND LOSSES. ESCALATING COSTS AT 5PC/YR TO 1972 COSTS GIVES AN ANNUAL COST OF $7.17E06. THE GAS IS ASSUMED TO COST $0.15/MCF AT A FOREIGN SITE. ON THIS BASIS, THE GAS COST FOR A 1.0E12/YR PLANT IS $2.47E04. ALLOCATION OF ANNUAL OPERATING COSTS TO 1.0E12 BTU/YR GIVES 6.38E04. ADDING THIS TO GAS COSTS GIVES A TOTAL ANNUAL OPERATING COST OF $8.85E04/1.0E12 BTU.

3049

VAPORIZATION BY COMBUSTION OF GAS IS ASSUMED. FROM (3008,408), THE 1970 EAST COAST BASIS CAPITAL COST FOR CONSTRUCTING AN LNG MARINE RECEIVING TERMINAL, INCLUDING A VAPORIZATION PLANT WITH A GROSS CAPACITY OF 1.0E9 SCFD, IS $58E06, EXCLUSIVE OF LAND

AND FUEL COSTS. FROM (3000,3-50), THE COST OF A 1.5E09 SCFD VAPORIZATION PLANT IS APPROXIMATELY 5PC OF THE TOTAL CAPITAL COST OF THE MARINE FACILITY, EXCLUSIVE OF LAND COSTS. ON THIS BASIS, THE 19[illegible] CAPITAL COST OF A 1.0E09 SCFD VAPORIZATION PLANT WOULD BE $2.9E06. ESCALATING TO 1972 COSTS USING THE CONSTRUCTION COST INDEX 1807/1380, ADDING 7PC OF COST FOR INTEREST DURING CONSTRUCTION AND USING A 10PC FIXED CHARGE RATE GIVES A FIXED COST OF $4.06E05 FOR THE VAPORIZATION PLANT. TO ALLOW FOR CONSUMPTION OF GAS AS FUEL, INPUT IS TAKEN AS 1.02 TIMES OUTPUT (3009,63). THE ALLOCATION OF CONSTRUCTION COSTS TO AN INPUT OF 1.0E12 BTU IS THUS $1.08E03/1.0E12 BTU. FROM (3000,2-29), THE ANNUAL OPERATING COST OF A VAPORIZATION PLANT IS TAKEN AS 6PC OF THE INVESTMENT PLUS THE COST OF GAS USED AS FUEL PLUS THE COST OF ELECTRIC POWER. THE INVESTMENT ALLOCATED TO 1.0E12 BTU IS $1.08E04. THE GAS USED AS FUEL IS ASSUMED TO COST $0.75/MCF FOR A TOTAL OF $1.46E04/1.0E12 BTU. POWER, AT 5 MILLS/KWH, FOR A 6.0E4 MMCF/YR OUTPUT VAPORIZATION PLANT AMOUNTS TO $2.19E04 (3000,2-259). THE PORTION ALLOCATED TO 1.0E12 BTU WOULD BE $347. THE TOTAL OPERATING COST IS THUS $1.55E04/1.0E12 BTU/YR.

3050

BASED ON AN LNG TANKER CAPACITY OF 120,000 M^3 (EQUIVALENT TO 2.62E09 CF OF 1034 BTU/CF GAS) (3008,391,428). FROM TABLE 9 (3008,389), THE QUOTED 1972 PRICE FOR U.S. CONSTRUCTION OF A 120,000 M^3 TANKER IS $72E06. INTEREST DURING CONSTRUCTION AT 7PC AND A 10PC FIXED CHARGE RATE GIVES A TOTAL CAPITAL COST OF $7.70E06. ALLOCATION TO 1.0E12 BTU/YR IS MADE ON THE BASIS OF 25 ROUND TRIPS (7000 MI/ROUND TRIP) TO GIVE $1.14E05/1.0E12 BTU/YR. FROM (3008,399), SHIP OPERATING COST/MCF DELIVERED AT 20 KNOTS IS $0.047/MCF ESCALATED AT 5PC/YR TO GIVE A 1972 COST OF $0.052/MCF OR $3.4E06 FOR A 120,000 M^3 TANKER MAKING 25 ROUND TRIPS/YR. OPERATING COSTS INCLUDE FIXED ANNUAL COSTS SUCH AS CREW, MAINTENANCE, TONNAGE DUES AND INSURANCE, AND VOYAGE RELATED EXPENSES SUCH AS PORT CHARGES, PILOT FEES, LINE HANDLERS, LIQUID NITROGEN EXPENSE AND COST OF BUNKER FUEL USED IN PORT. ALLOCATION TO 1.0E12 BTU/YR GIVES A TOTAL OPERATING COST OF $5.04E04/1.0E12 BTU.

3051

ABOVE GROUND METAL TANKS ARE ASSUMED. THE ESTIMATED 1972 COST OF CONSTRUCTION, INCLUDING INTEREST DURING CONSTRUCTION, IS $14.37/BBL OF CAPACITY (3000,2-201). A TANK CAPACITY OF 1.5 x 10^6 BBL IS ASSUMED, TWICE THE CAPACITY OF THE TANKER SUPPLYING THE FACILITY (3010,58). THIS GIVES A 1972 COST OF $21.54E06 FOR CONSTRUCTION COST OF THE TANKS INCLUDING PIPING AND SITE PREPARATION. TO PROVIDE THE 1.0E09 CFD REQUIRED BY THE VAPORIZATION FACILITY, THE TANKS MUST BE FILLED AND EMPTIED 74 TIMES/YR. THUS, THE ENERGY RATE IS 376.29E12 BTU/YR. USING A FIXED CHARGE RATE OF 10PC, AND ALLOCATING TO 1.0E12 BTU/YR, GIVES A FIXED COST OF $5.72E03/1.0E12 BTU. SUBTRACTING THE ESTIMATED CAPITAL COSTS OF THE TANK AND VAPORIZATION FACILITIES (SEE FOOTNOTE 3049) FROM THE CAPITAL COST OF THE ENTIRE FACILITY ($58E06 - FOOTNOTE 3049) GIVES THE APPROXI-

MATE CAPITAL COST OF THE MARINE AND SENDOUT FACILITIES OF THE TERMINAL. THIS AMOUNTS TO $33.56E06. FROM (3000,3-50), THE COST OF LAND IS 10PC ADDITIONAL OR $3.36E06. USING A 10PC FIXED CHARGE RATE, THE ADDITIONAL COST IS THEN $3.63E06. THE FIXED COST/1.0E12 BTU/YR IS THUS $9.81E03. ADDED TO THE COST OF THE TANK FACILITY, TOTAL FIXED COST IS $1.55E04/1.0E 12 BTU. THE 1970 EAST COAST OPERATING COST OF A 1.0E09 SCFD TERMINAL EXCLUDING FUEL AND CAPITAL CHARGES IS $3.6E06/YR (3008,409). THIS AMOUNTS TO $9.81E03/1.0E12 BTU. THIS INCLUDES THE OPERATING COST AND COST OF ELECTRIC POWER,BUT NOT FUEL FOR GAS-FIRED VAPORIZATION. FROM FOOTNOTE 3049, THE COST OF ELECTRIC POWER FOR VAPORIZATION IS $347/1.0E12 BTU, AND OTHER OPERATING COSTS ARE $648/1.0E12 BTU. SUBTRACTING THESE FROM THE TOTAL TERMINAL OPERATING COSTS GIVES $8.82E03/ 1.0E12 BTU/YR AS THE OPERATING COST OF THE TANK, MARINE AND SENDOUT FACILITIES.

3052

BASED ON THE AQUEOUS AMINE PROCESS. THE 1968 COST FOR A PLANT WITH AN INPUT OF 90 MMCFD IS ESTIMATED AS $4.15E6 (3000,2-50). ESCALATING TO 1972 DOLLARS USING CONSTRUCTION COST INDEX RATIO 1807/1154, AND USING 10P FIXED CHARGE RATE GIVES $6.49E5/YR. ALLOCATING TO 1.0E12 BTU/YR ON THE BASIS OF 330 STREAM-DAYS/ YR GIVES $2.12E4/1.0E12 BTU FIXED COST. OPERATING COSTS FOR STEAM, ELECTRIC ENERGY, AND CHEMICALS TOTAL $3.5E-3/MCF (3000, 2-50), WHICH CORRESPONDS TO $3400/1.0E12 BTU. ADDING A LABOR COST, ESTIMATED AT $2.0E-3/MCF, WHICH CORRESPONDS TO $1940/1.0 E12 BTU, GIVES AN OPERATING COST OF $5340/1.0E12 BTU.

3053

BASED ON A 1972 INVESTMENT OF $3.34E8 REPORTED FOR 12 PLANTS WITH A TOTAL CAPACITY OF 1759 MMCFD (3003). ASSUMING 330 STREAM-DAYS/YR, A 10P FIXED CHARGE RATE, AND ALLOCATION TO 1.0E12BTU/ YR GIVES $5.58E4/1.0E12 BTU. THE TOTAL COST IS ESTIMATED FROM THE AMOUNT OF NATURAL GAS PROCESSED IN 1971, 1.925E13 CF, AND THE 1971 VALUE OF THE PRODUCTS RECOVERED, $1.39E9,(0004,37). DEDUCTING AN ASSUMED 10P PROFIT AND ALLOCATING TO 1.0E12 BTU TREATED GAS GIVES A TOTAL COST OF $6.28E4/1.0E12 BTU. SUBTRACTING THE FIXED COST GIVES AN OPERATING COST OF $7000/E12 BTU.

3054

BASED ON AN AVERAGE VALUE OF 1.34 CENTS/GAL-100 MI TRUCKING RATE FOR LPG IN 1962 (2007,15-18). DEDUCTING AN ASSUMED 10P PROFIT AND ESCALATING TO 1972, USING AN ESTIMATED FACTOR OF 1.3,GIVES 1.57 CENTS/GAL-100 MI. ALLOCATION TO 1.0E12 BTU/YR GIVES $1.64/1.0E12BTU-100MI.

3055

BASED ON ESTIMATED CONSUMPTION OF 0.34P OF INPUT GAS USED TO GENERATE STEAM (SEE FOOTNOTE 3025).

3056

BASED ON 17PC OF INLET GAS USED A FUEL (3008,371).

3057

BASED ON A DAILY BOILOFF RATE OF 0.25P OF CARGO CAPACITY (3008, 392), AND A ROUND-TRIP DURATION OF 14.6 DAYS (INCLUDING AN AVERAGE DELAY TIME OF 2 DAYS/ROUND TRIP) (SOME LNG IS CARRIED

ON THE RETURN VOYAGE TO KEEP THE TANKS COLD). THE BOIL-OFF GAS IS USED AS PROPULSION FUEL, EXCEPT UNDER CONDITIONS OF LOW POWER DEMAND. ASSUMING THAT THE USAGE AS FUEL IS ABOUT 60PC OF THE TOTAL REQUIREMENT (3004,3), THE ADDITIONAL BTU INPUT FROM FUEL OIL IS 2.43E10 BTU/1.0E12 BTU.

3058

PHYSICAL LOSS OF LPG AND USE OF LPG AS TRUCK FUEL ARE ASSUMED TO BE NEGLIGIBLE. USING SAME BASIS AS FOOTNOTE 3002, THE AMOUNT OF DIESEL FUEL REQUIRED FOR A 200MI ROUND TRIP IS ESTIMATED TO BE 3.76E4 GAL/1.0E12 BTU. USING A CALORIC CONTENT OF 1.39 E5 BTU/GAL THE ENERGY INPUT IS 5.21E9 BTU/1.0E12 BTU FOR A 200 MI ROUND TRIP.

3059

EFFICIENCY IS BASED ON USE OF 2P OF LNG INPUT AS FUEL IN VAPORIZER (3000,2-252). THE ENERGY INPUT IS BASED ON AN ELECTRICAL POWER REQUIREMENT OF 69,400 KW-HR/1.0E12 BTU (FOOTNOTE 3049). USING A CONVERSION RATIO OF 3X3413 BTU/KWH GIVES AN ENERGY INPUT OF 7.11E8 BTU/1.0E12 BTU.

3060

LOSS OF GAS FROM THE TANK IS ASSUMED TO BE NEGLIGIBLE. THE BOIL-OFF GAS IS ASSUMED TO BE FUEL OR SENDOUT GAS (3000,2-202).

3061

FROM FOOTNOTE 3049, THE ELECTRIC POWER REQUIRED TO VAPORIZE 1.0E12 BTU IS 69,400 KWH. FROM (3010,60), THE POWER REQUIREMENTS FOR A 1.0E9 SCFD MARINE RECEIVING TERMINAL WITH 1.5 X 10^6 BBLS STORAGE CAPACITY, FILLED AND EMPTIED 74 TIMES/YR, ARE 17,000 KW 20PC OF THE TIME AND 14,000 KW 80PC OF THE TIME. THUS, THE TOTAL ANNUAL THROUGHPUT OF THE TERMINAL IS 365E09 SCF AT AN AVERAGE OF 1.28E08 KWH/YR. THIS AMOUNTS TO 3.49E05 KWH/1.0E12 BTU. SUBTRACTING THE POWER REQUIREMENT FOR THE VAPORIZATION FACILITY LEAVES 2.74E05 KWH/1.0E12 BTU. CONVERTING TO BTU'S AND MULTIPLYING BY 3 FOR THE EFFICIENCY OF ENERGY PRODUCTION GIVES A TOTAL OF 2.81E09 BTU/1.0E12 BTU AS THE ENERGY INPUT REQUIRED BY STORAGE, MARINE AND SENDOUT FACILITIES.

VI. POWER PLANT CONVERSION ACTIVITY OF FUEL SUPPLY

A. Introduction

Conversion to electric power is an activity which is part of the fossil and nuclear fuel supply chain. In this report, the environmental impacts of the power plant activity have all been compiled onto one table which should be considered as an addition to the supply impacts provided by Tables 1 through 25.

Table 26, the electric power conversion activity contains two processes for each of the three fossil fuels; coal, oil, and natural gas, and three for the nuclear system. Since the environmental impacts of the supply portion of the nuclear power plant trajectory are small, they have been aggregated and reported as one process in this table. The source of much of the information on Table 26 is a recent report prepared by the Council on Environmental Quality.* Whereas the CEQ report expressed all impacts on the basis of the output from a 1000 megawatt power plant, Table 26 is based on a 10^{12} Btu fuel input to each process.

Note that the power plant data are independent of one another and are for the national case only. A single national average fossil fuel power plant can be constructed from the data by combining the three different fueled plants in the appropriate ratio of electrical production by coal, oil, and gas.

Regional variations are not included in Table 26. The primary regional differences in power plant activity impacts will be because of the different sulfur and ash content of the regional coals and the different sulfur content of the regional oils. No significant regional differences will occur for natural gas fueled or nuclear plants.

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* Council on Environmental Quality, Energy and the Environment - Electric Power (Washington. U.S. Government Printing Office, 1973).

B. Impact Data Table and Footnotes

		UNCONTROLLED * CONTROLLED																	
		FUEL / REGION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		COAL, OIL AND NATURAL GAS / INTERNAL	WATER POLLUTANTS (TONS/ 10^{12} BTU, EX. COL. 12)												AIR POLLUTANTS			
					DISSOLVED SOLIDS													
ROW	MUL-TI-PLIER	ACTIVITY PROCESS (ELECTRIC POWER PROVI)	ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL BTU/10^{12}BTU	PARTIC-ULATES	NO_x	SO_2	HYDROCARBONS
1		COAL																
2		UNCONTROLLED																
3	ELGNR	ELECTRICITY GENERATION	1.37+01 3 1001	0000	0000	0000	3.01+01 2 1001	3.01+01 3	3.04+00 3 1001	3.71+00 3 1001	6.77+01 3	0000	0000	5.26+11 3 1002	8.22+01 3 1003	7.68+03 3 1003	2.02+03 1 1003	6.19+00
4	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
5																		
6		CONTROLLED																
7	ELGNR	ELECTRICITY GENERATION	0.00+00 3 1000	0.00+00 3 1000	0000	0000	1.82+01 4 1000	1.82+01 4	0.00+00 3 1000	1.02+03 3 1000	1.83+01 4	0000	0000	0.00+00 1 1010	2.06+01 3 1000	3.69+03 3 1000	2.02+03 1 1000	6.15+00
8	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
9																		
10																		
11		OIL																
12		UNCONTROLLED																
13	ELGNR	ELECTRICITY GENERATION	0000	0000	0000	0000	7.44+00 3 1010	7.44+00 3	7.09+01 3 1010	1.55+02 3 1010	8.18+00 3	0000	0000	5.26+11 2 1002	2.72+01 2 2001	3.57+02 3 2001	6.01+02 1 2001	6.01+00
14	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
15																		
16		CONTROLLED																
17	ELGNR	ELECTRICITY GENERATION	0.00+00 3 1017	0.00+00 3 1017	0000	0000	1.40+00 4 1017	1.40+00 4	0.00+00 3 1017	3.02+03 3 1017	5.40+00 4	0000	0000	0.00+00 1 1010	3.72+01 2 2004	3.57+02 3 2004	3.32+02 1 2004	9.31+00
18	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
19																		
20																		
21		NATURAL GAS																
22		UNCONTROLLED																
23	ELGNR	ELECTRICITY GENERATION	0000	0000	0000	0000	7.44+00 3 1010	7.44+00 3	7.09+01 3 1010	1.55+02 3 1010	8.18+00 3	0000	0000	5.26+11 2 1002	7.34+00 3 3001	1.91+02 3 3001	2.83+01 3 3001	1.00+00
24	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
25																		
26		CONTROLLED																
27	ELGNR	ELECTRICITY GENERATION	0.00+00 3 1017	0.00+00 3 1017	0000	0000	3.40+00 4 1017	3.40+00 4	0.00+00 3 1017	3.02+03 3 1017	3.40+00 4	0000	0000	0.00+00 1 1010	7.34+00 3 3001	1.91+02 3 3001	2.83+01 3 3001	1.00+00
28	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
29																		
30																		
31		NUCLEAR																
32		UNCONTROLLED																
33	EXTPR	EXTRACT-PROCESSING	0000	0000	0.00+00 2 0001	1.65-01 2 9604	4.10-01 2 9604	5.75-01 2	0.00+00 2 0001	0.00+00 2 0007	5.75-01 2	0000	0000	0.00+00 2 0007	9.68-02 2 9603	2.18-01 2 9603	1.73-01 2 9603	4.94-00
34	ELGNR	ELECTRICITY GENERATION	0000	0000	0000	0000	7.44+00 4 9612	7.44+00 4	7.09-01 4 9612	1.55-02 4 9612	8.18+00 4	0000	0000	6.60+11 1 9613	0.00+00 2 9608	0.00+00 2 9608	0.00+00 2 9608	0.00+00
35	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
36																		
37		CONTROLLED																
38	EXTPR	EXTRACT-PROCESSING	0000	0000	0.00+00 2 0007	1.65-01 2 9604	4.10-01 2 9604	5.75-01 2	0.00+00 2 0007	0.00+00 2 0007	5.75-01 2	0000	0000	0.00+00 2 0007	9.68-02 2 9603	2.18-01 2 9603	1.73-01 2 9603	4.94-00
39	ELGNR	ELECTRICITY GENERATION	0.00+00 3 9610	0.00+00 3 9610	0000	0000	3.40+00 4 9610	3.40+00 4	0.00+00 3 9610	3.02-03 3 9610	3.40+00 4	0000	0000	0.00+00 2 9611	0.00+00 2 9614	0.00+00 2 9614	0.00+00 2 9614	0.00+00
40	TRNSM	TRANSMISSION	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00 1 0007	0.00+00
41																		
42																		
43																		
44																		
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48																		
49																		
50																		

NOTE: ALL TABLE ENTRIES ARE BASED ON 10^{12} BTU OF RESOURCE INTO EACH PROCESS OR ACTIVITY.

SEE FOOTNOTE 1900 FOR A DESCRIPTION OF THE POWER PLANT ASSOCIATED WITH THE ELECTRIC POWER ACTIVITY.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/10^{12} BTU)									OCCUPATIONAL HEALTH						COST (DOLLARS/10^{12} BTU)			
NITRATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS TONS/10^{12} BTU	LAND (ACRE-YR/10^{12} BTU)	DEATHS/10^{12} BTU	INJURIES/10^{12} BTU	MAN-DAYS LOST/10^{12} BTU	POTENTIAL LARGE SCALE DISASTER	PRIMARY EFFICIENCY	ANCILLARY ENERGY BTU/10^{12} BTU	FIXED COST	OPERATING COST	TOTAL COST	ROW
																		1
																		2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
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																		6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14
																		15
																		16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18
																		19
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																		21
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23
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																		25
																		26
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27
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TABLE 26. ENVIRONMENTAL IMPACTS, EFFICIENCY AND COST FOR THE ELECTRIC POWER ACTIVITY OF UNCONTROLLED AND CONTROLLED COAL, OIL, NATURAL GAS, AND U-235 SUPPLY

1900

ENTRIES IN THE TABLE ARE BASED ON AN ENERGY INPUT TO EACH PROCESS OF 1.0E12 BTU. FOR THE TRANSMISSION PROCESS, THE BTU'S ARE THE EQUIVALENT OF 2.93E8 KWH INPUT. POWER PLANT CONVERSION OF FOSSIL FUEL TO ELECTRICITY, INCLUDING TRANSMISSION, IS AN ACTIVITY WHICH SHOULD BE CONSIDERED PART OF EACH FOSSIL FUEL SUPPLY MATRIX.

1901

ALTHOUGH RELIABLE DATA ARE NOT AVAILABLE, THE FOLLOWING ESTIMATES WERE DERIVED FROM (1921,110,115,122,129,132,216) AND (1922, 20,22). SOURCES OF WATER POLLUTANTS INCLUDE DEMINERALIZER REGENERATIONS, ASH SLUICING, BOILER BLOW-DOWNS, CLARIFICATION WASTES, COAL PILE RUNOFF, AND MISCELLANEOUS CLEANING AND DRAIN WASTES. ONLY THE ACIDITY FROM THE COAL PILE RUNOFF IS SHOWN BELOW.

WATER POLLUTANTS-TONS/10^{12} BTU

ACIDITY	25.7
TOTAL DISSOLVED SOLIDS	58.1
SUSPENDED SOLIDS	6.84
ORGANICS	2.71

1902

BASED ON A POWER PLANT EFFICIENCY OF 38P, 62P OF THE BTU INPUT IS REJECTED HEAT. OF THIS, ONE-SIXTH IS REJECTED WITH THE STACK GASES. FROM (1901,11/13).

1903

EMISSION FACTORS ARE FROM (0002,1-3). THEY APPLY TO A 'GENERAL' PULVERIZED-FEED FURNACE OF OVER 1.0E3 BTU/HOUR WITH PARTICULATES CONTROLLED TO 98%. FROM (1903) ASH CONTENT IS 12.53 PC AND SULFUR CONTENT IS 2.59 PC. THERE ARE 41,000 TON COAL/ 1.0E12 BTU (FOOTNOTE 1000).

AIR EMISSIONS FROM POWER PLANT - TONS/1.0E12 BTU

PARTICULATES	82.2
SULFUR OXIDES	2017.0
CARBON MONOXIDE	20.5
HYDROCARBONS	6.15
NITROGEN OXIDES	369.0
ALDEHYDES	0.103

NOTE- AN INSIGNIFICANT AMOUNT (EQUIVALENT TO APPROXIMATELY 2.2 CURIES) OF RADIOACTIVITY IS EMITTED ANNUALLY FROM A 1000 MWE COAL-FIRED PLANT. THIS FIGURE WAS DERIVED FROM (1904,27).

1904

IN FOOTNOTE 1903 IT WAS STATED THAT 12.53 PC OF THE COAL BURNED BECOMES ASH. OF THIS 5137 TONS, 82.2T/1.0E12 BTU ARE EMITTED TO THE AIR AS FLYASH AND THE REMAINDER, 5055T/1.0E12 BTU IS SOLID WASTE.

1905

TYPICAL PLANT SIZE FOR 3000 MWE PLANTS WITH FLY ASH CONTROLS IS 1200 ACRES, INCLUDING 350 FOR ASH STORAGE AND 40 FOR COAL STORAGE. SOURCE- (1905,11,14).

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1906

SOURCE- (1906,46). 0.166 MEN PER MWE IS THE BASIS FOR THE CALCULATION. INJURY DATA ARE FROM (1907,35). HALF THE COMBINED DEATHS AND PERMANENT INJURIES ARE ASSUMED TO BE FATAL INJURIES. PERMANENT TOTAL DISABILITIES ARE CONSIDERED TO REPRESENT 6000 DAYS LOST WHILE OTHER DISABILITIES ARE ESTIMATED AS 100 DAYS LOST. MAN-DAYS LOST ARE FOR INJURIES ONLY.

1907

BASED ON ESTIMATED LAND RIGHT-OF-WAY OF 4 MILLION ACRES. SOURCE (1908,111). MULTIPLIED BY .00430, THE SHARE OF TOTAL 1970 U.S. ELECTRICITY PRODUCTION REPRESENTED BY A 1000 MWE PLANT (6.57E9 KWH). SOURCE (1909,11). 1.0E12 BTU IS EQUIVALENT TO 2.93E8 KWH (SEE FOOTNOTE 1900).

1908

THE BASIS FOR WATER POLLUTANT CALCULATIONS IS THE PROPOSED EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS FOR THE STEAM ELECTRIC POWER GENERATING POINT SOURCE CATEGORY GIVEN IN (1921). FOR NEW PLANTS, BEST AVAILABLE DEMONSTRATED CONTROL TECHNOLOGY (BADCT) REQUIRES EFFLUENT PH CONTROL IN THE RANGE OF 6-9. HENCE ACIDS AND BASES DISCHARGE WILL BE NEGLIGIBLE. BADCT ALSO SPECIFIES TOTAL SUSPENDED SOLIDS LEVELS NO GREATER THAN 15 MG/L FOR ALL INTERMEDIATE AND LOW VOLUME WASTE EFFLUENTS. AT THIS LEVEL OF CONTROL THERE WILL GENERALLY BE NO NET INCREASE IN SUSPENDED SOLIDS IN WATER PASSING THROUGH THE POWER PLANT SYSTEM. ORGANICS (OIL AND GREASE) MUST BE CONTROLLED TO 10 MG/L TO MEET BADCT STANDARDS. HENCE FROM (1921,232) THESE EMISSIONS WILL AMOUNT TO .0736 TON ORGANICS/10^6 TON COAL OR 3.02-03 TON/10^{12} BTU. INFORMATION ON THE INCREASE IN TOTAL DISSOLVED SOLIDS OF WATER USED IN POWER PLANTS IS NOT READILY AVAILABLE AND WAS SYNTHESIZED FROM (1922,10,12,20,22). BASED ON THIS DATA THE NET INCREASE IN TOTAL DISSOLVED SOLIDS FOR WATER USED BY THE POWER PLANT IS 18.2 TON/10^{12} BTU.

1909

ASSUMES WET LIME SCRUBBER SYSTEM FOR BOTH SO_x AND PARTICULATE CONTROL WITH REMOVAL EFFICIENCIES TAKEN AT 90 P FOR SO_x AND AN OVERALL OF 99.5P FOR PARTICULATES FROM (1923,31).

1910

BASED ON 33 CF/TON FLY ASH AND 26 CF/TON WET LIME SLUDGE FROM (1925,57), THE INCREMENTAL SOLID WASTE (FOOTNOTE 1911) HAS A VOLUME OF 2.49E5 FT^3/1.0E12 BTU. ASSUMING ONSITE DISPOSAL TO A DEPTH OF 30 FT, .191 AC/1.0E12 BTU IS AFFECTED. TIME AVERAGING OVER 30 YR OF PLANT LIFE THIS BECOMES 2.87 AC-YR/1.0E12 BTU. FROM (1926,45) COOLING TOWERS ARE ESTIMATED TO OCCUPY 10 ACRES FOR A 1000 MWE PLANT OR .130 AC-YR/1.0E12 BTU. THESE LAND REQUIREMENTS ARE IN ADDITION TO THE LAND IMPACT OF FOOTNOTE 1905, 8.49 AC-YR/1.0E12 BTU.

1911

BASED ON (1924,25) AND 50P SOLIDS IN THE SLURRY, .232 TON SLUDGE IS PRODUCED/TON COAL OR 9512 TON SLUDGE/10^{12} BTU. FROM FOOTNOTES 1904 and 1909 THE INCREMENTAL FLY ASH COLLECTED AS SOLID WASTE AMOUNTS TO 61 TON/10^{12} BTU. HENCE THE SUM TOTAL INCREMENTAL SOLID WASTE PRODUCED IS 9573 TON/10^{12} BTU. THIS IS IN ADDITION TO THE SOLID WASTE FROM FOOTNOTE 1904-5055 TON/10^{12} BTU.

1912

A LARGE NEW POWER PLANT IS ASSUMED TO HAVE A HEAT RATE OF 8960 BTU/KWH, EQUIVALENT TO 38P CONVERSION EFFICIENCY. THE BEST PLANTS HAVE ACHIEVED AROUND 8530-8900, WHEREAS THE NATIONAL AVERAGE IS AROUND 10,500 (1913,I-5-6/I-5-7).

1913

POWER SOLD DIVIDED BY POWER PRODUCED, 1969 (1919,11,13).

1914

COSTS OF COAL FIRED POWER PLANTS ESTIMATED AT $180/KW (1914) AND (1915). OPERATION AND MAINTENANCE COSTS EXCLUSIVE OF FUEL COSTS ESTIMATED AT 0.71 MILLS/KWH (1918,45). A 60P LOAD FACTOR IS ASSUMED AND THE FCR FOR CAPITAL IS 10P.

1915

CAPITAL AND OPERATING COSTS FOR CONTROLS ARE ESTIMATED AS FOLLOWS:

CONTROL SYSTEM	CAPITAL COST- $/KW	REF	OPERATING COST MILLS/KWH	REF
WATER POLL-CHEMICAL	1	(1921,233)	.05	(1921,234)
WATER POLL-THERMAL	10	(1915)	.05	(1920,III-3)
AIR POLL-SOx REMOVAL	40	(1923,60,61) & (1911,4/18)	1.07	(1923,18/28)
TOTAL	51		1.17	

BASED ON THE ABOVE, A 60P LOAD FACTOR AND A NET PLANT HEAT RATE OF 9224 BTU/KWH (37P PRIMARY EFFICIENCY FROM FOOTNOTE 1919) THE INCREMENTAL CAPITAL COST IS 1.05+05 $/1.0E12 BTU AND THE INCREMENTAL OPERATING COST IS 1.27+05 $/1.0E12 BTU. THESE ARE IN ADDITION TO THE COSTS GIVEN IN FOOTNOTE 1914.

1916

ALTHOUGH RELIABLE DATA ARE NOT AVAILABLE, THE FOLLOWING ESTIMATES WERE DERIVED FROM (1921,110,115,122,129,132,216) AND (1922,20,22). SOURCES OF WATER POLLUTANTS INCLUDE DEMINERALIZER REGENERATIONS, BOILER BLOWDOWNS, CLARIFICATION WASTES, AND MISCELLANEOUS CLEANING AND DRAIN WASTES.

	WATER POLLUTANTS-TONS/10^{12} BTU
TOTAL DISSOLVED SOLIDS	7.44
SUSPENDED SOLIDS	0.709
ORGANICS	0.0155

1917

THE BASIS FOR WATER POLLUTANT CALCULATIONS IS THE PROPOSED EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS FOR THE STEAM ELECTRIC POWER GENERATING POINT SOURCE CATEGORY GIVEN IN (1921). FOR NEW PLANTS, BEST AVAILABLE DEMONSTRATED CONTROL TECHNOLOGY (BADCT) REQUIRES EFFLUENT PH CONTROL IN THE RANGE OF 6-9. HENCE ACIDS AND BASES DISCHARGE WILL BE NEGLIGIBLE. BADCT ALSO SPECIFIES TOTAL SUSPENDED SOLIDS LEVELS NO GREATER THAN 15 MG/L FOR ALL INTERMEDIATE AND LOW VOLUME WASTE EFFLUENTS. AT THIS LEVEL OF CONTROL THERE WILL GENERALLY BE NO NET INCREASE IN SUSPENDED SOLIDS IN WATER PASSING THROUGH THE POWER PLANT SYSTEM. ORGANICS (OIL AND GREASE) MUST BE CONTROLLED TO 10 MG/L TO MEET BADCT STANDARDS. HENCE, FROM (1921,232) THESE EMISSIONS WILL AMOUNT TO 3.02-03 TON/10^{12} BTU. INFORMATION ON THE INCREASE IN TOTAL DISSOLVED SOLIDS OF WATER USED IN POWER PLANTS IS NOT READILY AVAILABLE AND WAS SYNTHESIZED FROM (1922,10,12,20,22). BASED ON THIS DATA THE NET INCREASE IN TOTAL DISSOLVED SOLIDS FOR WATER USED BY THE POWER PLANT IS 3.40 TON/10^{12} BTU.

FTN. 1918-2907

1918

THERMAL DISCHARGES ARE ASSUMED TO BE COMPLETELY ELIMINATED BY THE USE OF MECHANICAL DRAFT WET COOLING TOWERS.

1919

ENERGY REQUIREMENTS FOR CONTROLS ON A 500 MWE PLANT ARE ESTIMATED AS FOLLOWS:

CONTROL SYSTEM	ENERGY REQUIRED-KW	REFERENCE
WATER POLL-CHEMICAL	22.4	(1921,234)
WATER POLL-THERMAL	5000.0	(1921,446)
AIR POLL-SO_X REMOVAL	9230.0	(1911,25,26)
TOTAL	14252.4	

THIS AMOUNT TO 2.85P OF THE POWER PLANT OUTPUT OR 14.25 MWE. BASED ON THIS THE POWER PLANT OUTPUT IS DERATED TO 485.75 MWE AND THE PRIMARY EFFICIENCY IS REDUCED FROM .38 TO .37 (SEE FOOTNOTE 1912).

2901

AIR EMISSIONS, CONSIDERING 1.5P SULFUR IN THE FUEL (ESTIMATED WEIGHTED AVERAGE FROM (2020,42)), ARE CALCULATED FROM (0002, 1-7).

AIR EMISSIONS - POWER PLANT
(TONS/1.0E12 BTU)

PARTICULATES	SOX	CO	HC	NOX	ALDEHYDES
27.2	801	0.138	6.81	357	3.40

2902

THE LAND REQUIRED FOR A 3000 MWE PLANT, IS GIVEN AS 350 ACRES IN (1905,11).

2903

SEE FOOTNOTE 1906, USING 0.094 MEN PER MWE.

2904

BASED ON THE USE OF 0.6P SULFUR RESIDUAL FUEL FROM DATA IN (1906). SEE ALSO FOOTNOTE 2901.

2905

.130 AC-YR/1.0E12 BTU ARE ADDED FOR COOLING TOWERS (SEE FOOTNOTE 1910).

2906

COSTS OF OIL FIRED POWER PLANTS ESTIMATED AT $150/KW (1914) AND (1915). OPERATION AND MAINTENANCE COSTS EXCLUSIVE OF FUEL COSTS ESTIMATED AT 0.43 MILLS/KWH (1918,45). A 60P LOAD FACTOR IS ASSUMED AND THE FCR FOR CAPITAL IS 10P.

2907

CAPITAL AND OPERATING COSTS FOR CONTROLS ARE ESTIMATED AS FOLLOWS:

CONTROL SYSTEM	CAPITAL COST- $/KW	REF	OPERATING COST- MILLS/KW-HR	REF
WATER POLL-CHEMICAL	1	(1921,233)	.05	(1921,234)
WATER POLL-THERMAL	10	(1915)	.05	(1920,III-3)
TOTAL	11		.10	

BASED ON THE ABOVE, A 60P LOAD FACTOR AND A NET PLANT HEAT RATE OF 9053 BTU/KWH (37.7P PRIMARY EFFICIENCY FROM FOOTNOTE 2908) THE INCREMENTAL CAPITAL COST IS 2.31+04 $/1.0E12 BTU AND THE INCREMENTAL OPERATING COST IS 1.10+04 $/1.0E12 BTU. THESE ARE IN ADDITION TO THE COSTS GIVEN IN FOOTNOTES 2906 AND 3905. NOTE THAT INCREMENTAL FUEL COSTS ASSOCIATED WITH PURCHASING A .6P SULFUR RESIDUAL OIL (FOR OIL FIRED POWER PLANTS) ARE NOT INCLUDED IN THE ABOVE ANALYSIS. ALTHOUGH PROPERLY ATTRIBUTED TO AIR POLLUTION CONTROL COSTS, THE COST OF FUEL IS NOT CONSIDERED IN THE OPERATING AND MAINTENANCE

COSTS OF THE UNCONTROLLED CASE AND HENCE AN INCREMENTAL FUEL COST IS NOT GIVEN FOR THE CONTROLLED CASE.

2908

ENERGY REQUIREMENTS FOR CONTROLS ON A 500 MWE PLANT ARE ESTIMATED AS FOLLOWS:

CONTROL SYSTEM	ENERGY REQUIRED-KW	REFERENCE
WATER POLL-CHEMICAL	22.4	(1921,234)
WATER POLL-THERMAL	5000.0	(1921,446)
TOTAL	5022.4	

THIS AMOUNTS TO 1P OF THE POWER PLANT OUTPUT OR 5 MWE. BASED ON THIS THE POWER PLANT OUTPUT IS DERATED TO 495 MWE AND THE PRIMARY EFFICIENCY IS REDUCED FROM .38 TO .377 (SEE FOOTNOTE 1912).

3901

AIR EMISSIONS COMPONENTS (TONS/1.0E12 BTU) FROM (0002,1-9)

PARTICULATES	SOX	CO	HC	NOX	ALDEHYDES, ETC.
7.34	.293	.190	19.6	191	3.43

3902

THE AVERAGE GAS FUELED POWER PLANT SITE FOR A 3000 MWE UNIT IS ESTIMATED AT 200 ACRES (1905,11).

3903

SEE FOOTNOTE 1906, USING 0.089 MEN PER MWE.

3904

NOTE THAT THE ONLY CONTROLS UTILIZED ARE COOLING TOWERS TO PREVENT THERMAL DISCHARGE TO WATER. TEN ACRES ARE NEEDED FOR THE COOLING TOWERS WITH A 1000 MWE PLANT. LAND USE FOR A 1.0E12 BTU PLANT (INPUT) IS .130 AC-YR (SEE FOOTNOTE 1910). THIS IS IN ADDITION TO THE LAND FROM FOOTNOTE 3902.

3905

COST OF GAS FIRED POWER PLANT AT $100/KW (1914) AND (1915). OPERATING AND MAINTENANCE COST EXCLUSIVE OF FUEL COST AT 0.51 MILLS/KWH (1906,45). A 60P LOAD FACTOR IS ASSUMED AND THE FCR FOR CAPITAL IS 10P.

9600

FROM (9600,55) FOR THE ACTIVITIES OF EXTRACTION, PROCESSING, AND TRANSPORTATION.

9601

FROM (9600,55) FOR THE CONVERSION ACTIVITY.

9602

POWER SOLD DIVIDED BY POWER PRODUCED IN 1969 (1919,11,13).

9603

FROM (9601,S-14) LESS THOSE EMISSIONS DUE TO ELECTRICITY GENERATION (9601,S-13,D-17) AND BASED ON 1.235 TON U-235/ANNUAL FUEL REQUIREMENT (9601,S-5). SEE ALSO FOOTNOTE 9600 AND (9600,56). FROM (9601,S-15) 2.05+03 CURIES/10^{12} BTU IN ARE RELEASED TO THE THE ATMOSPHERE.

9604

FROM (9601,S-14) AND BASED ON 1.235 TON U-235/ANNUAL FUEL REQUIREMENT (9601,S-5). SEE ALSO FOOTNOTE 9600 AND (9600,56). FROM (9601,S-15) 14 CURIES/10^{12} BTU IN ARE RELEASED TO WATER BODIES AND 3.36 CURIES/10^{12} BTU IN TO LAND.

9605

FROM (9600,57) FOR THE ACTIVITIES OF EXTRACTION, PROCESSING, AND TRANSPORTATION. BASED ALSO ON FOOTNOTE 9600 AND (9600,55).

9606

FROM (9600,55) FOR THE CONVERSION ACTIVITY. BASED ALSO ON FOOTNOTE 9600 AND (9600,55).

9607

FROM (9601,S-13) AND BASED ON 1.235 TON U-235/ANNUAL FUEL REQUIREMENT (9601,S-5). SEE ALSO FOOTNOTE 9600 AND (9600,56).

9608

FROM (9600,57) AIR EMISSIONS ARE NEGLIGIBLE. HOWEVER 1.94+03 CURIES/10^{12} BTU IN ARE RELEASED TO THE ATMOSPHERE.

9609

CONSIDERED AS PART OF WASTE MANAGEMENT IN THE EXTRACTION ACTIVITY. 4.36+02 CURIES/10^{12} BTU ARE BURIED IN THE GROUND (9600,57).

9610

BASED ON (9600,57) FOR THE CONVERSION ACTIVITY.

9611

BASED ON $300/KW FROM (9600,58), A 0.75 LOAD FACTOR, 31P PLANT EFFICIENCY AND ANNUALIZED AT 10P/YR. OPERATION, MAINTENANCE, AND INSURANCE COSTS ESTIMATED AT 0.99 MILLS/KWH FROM (9600, 58).

9612

SEE FOOTNOTE 1916 FOR CHEMICAL WATER POLLUTANTS. FROM (9600,57) 4.59 CURIES/10^{12} BTU IN ARE RELEASED TO WATER BODIES.

9613

BASED ON A 31P EFFICIENT PLANT AND ONCE THROUGH COOLING (SEE FOOTNOTE 9601).

9614

REDUCING POWER PLANT RADIATION EMISSIONS BY 99P IS ESTIMATED TO COST $4E6 FOR A 1000 MWE PLANT (9600,58). THUS AT A 10P FIXED CHARGE RATE FOR CAPITAL COST THIS AMOUNTS TO 5.53+03 $/$10^{12}$ BTU IN. THE RADIOACTIVE EMISSIONS THEN BECOME 1.94+01 CURIES/ 10^{12} BTU (SEE FOOTNOTE 9608).

9615

THERMAL DISCHARGES ARE ASSUMED TO BE COMPLETELY ELIMINATED BY THE USE OF COOLING TOWERS. CAPITAL COST IS ESTIMATED AT $14/KW (9600,58), AND OPERATING COST IS TAKEN AS 0.05 MILLS/KWH (1920,III-3). A 75P LOAD FACTOR IS ASSUMED AND THE CAPITAL COST IS ANNUALIZED A 10P (SEE ALSO FOOTNOTE 9616).

9616

ENERGY REQUIREMENTS FOR CONTROLS ON A 500 MWE PLANT ARE ESTIMATED AS FOLLOWS:

CONTROL SYSTEM	ENERGY REQUIRED-KW	REFERENCE
WATER POLL-CHEMICAL	22.4	(1921,234)
WATER POLL-THERMAL	5000.0	(1921,446)
TOTAL	5022.4	

THIS AMOUNTS TO 1P OF THE POWER PLANT OUTPUT OR 5 MWE. BASED ON THIS THE POWER PLANT OUTPUT IS DERATED TO 495 MEW AND THE PRIMARY EFFICIENCY IS REDUCED FROM 0.31 TO 0.307 (SEE FOOTNOTE 9601).

9617

BASED ON 14 ACRES FOR COOLING TOWERS FOR A 1000 MWE PLANT IN (9600,58). SEE ALSO FOOTNOTE 9610.

9618

SEE FOOTNOTE 1916 FOR CHEMICAL WATER POLLUTANTS AND FOOTNOTE 9612 FOR RADIOACTIVE DISCHARGES.

9619

CAPITAL AND OPERATING COSTS FOR CONTROLS ARE ESTIMATED AS FOLLOWS:

CONTROL SYSTEM	CAPITAL COST- $/KW	REF	OPERATING COST- MILLS/KWH	REF
WATER POLL-CHEMICAL	1	(1921,233)	0.05	(1921,234)
WATER POLL-THERMAL	14	(9600,58)	0.05	(1920, III-3)
AIR POLL-RADIOACTIVE	4	(9600,58)	--	
TOTAL	19		0.10	

BASED ON THE ABOVE, A 75P LOAD FACTOR AND A PLANT HEAT RATE OF 11,121 BTU/KWH (30.7P PRIMARY EFFICIENCY FROM FOOTNOTE 9616) THE INCREMENTAL CAPITAL COST IS 2.60+04 $/10^{12} BTU IN (FCR IS 10P/YR) AND THE INCREMENTAL OPERATING COST IS 8.99+03 $/10^{12} BTU IN. THESE ARE IN ADDITION TO THE COSTS GIVEN IN FOOTNOTE 9611.

VII. RESIDENTIAL END USE

A. Introduction

Table 27 represents the end use rates and environmental impacts in the residential end use sector. The measures "dwelling-year," and "unit-year," the latter referring to a single item in average use, were selected primarily for convenience in the updating of data. Most multipliers are from the 1970 Census of Housing, with some for minor appliances coming from the 1969 Starch market profile, scaled up to 1970 by the rate of dwelling unit population growth.

Since the 1970 Census multipliers are very "hard," 1970 was chosen as the base year for this section. Independent estimates of total 1970 residential energy for each "fuel," including electricity, are in each case within 10 percent of the amounts calculated by multiplying out the table and summing over activities for each fuel. Conceptually, the activities and fuels identified in the table cover over 95 percent of all residential energy use.

While the principal end use rates (those for direct heat, etc.) are well established statistics from the American Gas Association, the Edison Electric Institute, or calculated from Bureau of Mines petroleum data in conjunction with Census figures, some use rates are subject to assumptions stated clearly in the footnotes. In particular, the use rates for room and central air conditioning are dependent upon the assumed average rated capacities of the various units.

All air emission factors are derived from EPA's compilation (Ref. 0002). Those for space heat and water heat are judged to be very accurate, while those obtained through correction factors (from the San Francisco Bay Area Air Pollution Control District) are only rough approximations. The orders of magnitude of these factors (for gas dryers, ranges, etc.) are believed correct, and their contribution to total residential air emissions is small. Only an SO_x factor is included for gas lamps (yard lights) because relevant emissions are not presently available.

In this sector no significant environmental effects other than air pollution are energy-related.

Multipliers in this section may be escalated to 1971, 1972, or 1973 without serious error by application of the 1.3 percent yearly population gain figure for 1969-1971, from the 1972 Statistical Abstract.

B. Impact Data Table and Footnotes

ROW	NUMBER-ICON	END USE SECTOR: RESIDENTIAL — END USE	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/MEAS.)	13 AIR POLLUTANTS PARTIC-ULATES	14 NO_x	15 SO_x
			WATER POLLUTANTS (TONS/MEASURE, EX. COL. 12)														
1		SPACE HEAT - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.13-03 3 5020	3.03-03 3 5020	3.40-06 3 5020
2		SPACE HEAT - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.21-03 3 5027	3.02-03 3 5027	7.00-04 3 5026
3		SPACE HEAT - DSTL	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 0007	0.00+00 3 0007	0000	0000	0000	3.01-03 3 5027	8.01-03 3 5027	1.07-02 3 5030
4		SPACE HEAT - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
5		WATER HEAT - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.40-04 3 5021	7.23-04 3 5021	7.14-00 3 5021
6		WATER HEAT - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.02-04 3 5021	8.25-04 3 5021	1.52-00 3 5020
7		WATER HEAT - DSTL	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 0007	0.00+00 3 0007	0000	0000	0000	1.26-03 3 5022	1.10-02 3 5022	5.02-01 3 5022
8		WATER HEAT - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
9		CLOTHES DRY - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.30-06 4 5033	1.02-04 4 5033	2.02-05 4 5033
10		CLOTHES DRY - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
11		CENTRAL A/C - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.72-06 4 5033	1.06-03 4 5033	1.00-05 4 5033
12		CENTRAL A/C -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
13		ROOM A/C -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
14		STD OVEN-RANGE - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.00-05 3 5033	1.13-04 3 5033	3.08-00 3 5033
15		STD OVEN-RANGE - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.01-04 3 5033	1.00-04 3 5033	5.00-05 3 5033
16		STD OVEN-RANGE - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
17		AUTO-CLEAN OVEN-RANGE - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.01-04 3 5033	1.00-04 3 5033	2.07-04 4 5033
18		AUTO-CLEAN OVEN-RANGE - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.00-04 3 5033	2.07-04 4 5033	8.10-05 3 5033
19		AUTO-CLEAN OVEN-RANGE - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
20		AUTO WASHER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
21		MANUAL WASHER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
22		DISHWASHER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
23		B&W TV STD-ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
24		COLOR TV STD -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
25		B&W TV INST-ON -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
26		COLOR TV INST-ON -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
27		STD REFRIGERATOR -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
28		NO FROST REFRIGERATOR -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
29		STD REFR-FREEZER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
30		NO FROST REFR-FREEZER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
31		STD FREEZER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
32		NO FROST FREEZER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
33		YARD LIGHT -NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
34		INCANDESC LIGHT -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	5.26-00 3 5034
35		FLUORESC LIGHT -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
36		COFFEE POT -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
37		FRY PAN -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
38		HAND IRON -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
39		BLANKET -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
40		DEHUMIDIFIER -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
41		ATTIC FAN -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
42		FURNACE FAN -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
43		SOLE HEAT FAN -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
44		WATER PUMP -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
45		RADIO -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
46		RADIO-PHONO -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
47		VACUUM CLEAN -ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
48		LAWN & GARDEN ENGINES -GASO.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.05-04 3 5035	2.01-04 3 5035	2.40-00 3 5035
49																	
50																	

NOTE: ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE FOSSIL FUEL EQUIVALENT OF ELECTRICITY.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/MEASURE)									OCCUPATIONAL HEALTH									
PARTICULATES	NO_x	SO_x	HYDROCARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/MEAS)	LAND (ACRES)	DEATHS MEAS	INJURIES MEAS	MAN-DAYS LOST/MEAS	POTENTIAL LARGE SCALE DISASTER	FUEL	MEASURE	ENERGY (BTU/MEAS)	MULTIPLIER	MULTIPLIER YEAR	ROW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	NATURAL GAS	DWELLING-YR	[illegible]	[illegible]	1970	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	L.P.G.	DWELLING-YR	[illegible]	[illegible]	1970	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	DISTILLATE	DWELLING-YR	[illegible]	[illegible]	1970	3
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	NATURAL GAS	DWELLING-YR	[illegible]	[illegible]	1970	5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	L.P.G.	DWELLING-YR	[illegible]	[illegible]	1970	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	DISTILLATE	DWELLING-YR	[illegible]	[illegible]	1970	7
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	NATURAL GAS	UNIT-YEAR	[illegible]	[illegible]	1970	9
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	10
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	NATURAL GAS	DWELLING-YR	[illegible]	[illegible]	1970	11
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	12
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	13
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	NATURAL GAS	DWELLING-YR	[illegible]	[illegible]	1970	14
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	L.P.G.	DWELLING-YR	[illegible]	[illegible]	1970	15
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	NATURAL GAS	DWELLING-YR	[illegible]	0999		17
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	L.P.G.	DWELLING-YR	[illegible]	0999		18
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	0999		19
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	20
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	21
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	22
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	23
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	24
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	0999		25
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	0999		26
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	27
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	28
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	29
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	30
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	31
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	32
0000	0000	[illegible]	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	NATURAL GAS	UNIT-YEAR	[illegible]	[illegible]	1972	33
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	34
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	DWELLING-YR	[illegible]	[illegible]	1970	35
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	36
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	37
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	38
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	39
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	40
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	[illegible]	41
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	[illegible]	42
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	43
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	44
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	45
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	46
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	UNIT-YEAR	[illegible]	[illegible]	1970	47
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	GASOLINE	UNIT-YEAR	[illegible]	[illegible]	1971	48
																		49
																		50

TABLE 27. ENVIRONMENTAL IMPACTS AND EFFICIENCY OF RESIDENTIAL ENERGY USE

5001

BTU/ DWELLING-YR FROM (5101,55) WHICH ASSUMES 5000 ANNUAL DEGREE HEATING DAYS. NUMBER OF OCCUPIED DWELLINGS WITH NATURAL GAS, LPG HEAT FROM (5102). USE RATE IS STATISTICALLY DERIVED, AND REPRESENTS AN AVERAGE SIZE DWELLING WITH AVERAGE INSULATION, USE PATTERNS ETC. FOR CONTEXT,A 1700 SF TWO STORY WOOD FRAME HOUSE, SYNTHESIZED TO REPRESENT THE BALTIMORE-WASHINGTON AREA, USES ABOUT 1.36E+08 BTU/YEAR FOR GAS FORCED AIR HEAT, FROM (5106,12-42).

5002

BASED ON 2.51E+15 BTU DISTILLATE PLUS KEROSENE INTO RESIDENTIAL SECTOR, FROM (0007, 38/40). WE SUBTRACT 2.15E+14 BTU TOTAL COMPUTED FOR WATER HEAT TO GET AMOUNT FOR SPACE HEAT, THE ONLY OTHER IMPORTANT USE. NUMBER OCCUPIED UNITS USING DISTILLATE (OR KEROSENE- A SMALL NUMBER) FROM (5102).

5003

FROM (5112). MULTIPLIER IS FROM (5102)

5004

FROM (5101,55). MULTIPLIER IS FROM (5102) ASSUMES NAT. GAS AND LPG HAVE SAME EFFICIENCY AND USE PATTERNS.

5005

BASED ON RATE FOR GAS WATER HEAT. ASSUMES FACTORS OTHER THAN TECHNICAL EFFICIENCY SAME FOR OIL, GAS WATER HEAT. SEE ALSO FOOTNOTE 5002. TECHNICAL EFFICIENCY OIL,GAS WATER HEAT ARE 50P, 64P, RESPECTIVELY (0007,38). MULTIPLIER IS FROM (5102)

5006

FROM (5102). ASSUMES HALF OF ALL UNITS ARE QUICK RECOVERY TYPE (5103).

5007

FROM (5101,55). MULTIPLIER IS FROM (5102).

5008

FROM (5104). MULTIPLIER IS FROM (5102).

5009

BASED ON 31E+06 BTU/YR PER 12000 BTUH CAP UNIT (5101,55). ASSUMES AVERAGE UNIT IS 24000 BTUH CAP; SEE FOOTNOTE 5010. MULTIPLIER ASSUMES 3P TOTAL ARE GAS UNITS (0007).TOTAL UNITS FROM (5102)

5010

FROM (5104).AVERAGE CENTRAL UNIT 3350 WATT RATING CORRESPONDS TO 24000 BTUH CAP, FROM (5114).MULTIPLIER IS FROM (5102)

5011

FROM (5103);AVERAGE ROOM UNIT DRAWS 1500 WATTS, EQUIVALENT TO 10000 BTUH CAP, FROM (5113). MULTIPLIER IS FROM (5102)

5012

FROM (5103).MULTIPLIER IS FROM (5102).

5013

BASED ON 40000 BTU/CYCLE (5105).ASSUMES 12 CYCLES/YR. NO ADJUSTMENTS FOR SUPERIOR INSULATION (5101,55). NO MULTIPLIER AVAILABLE BUT IS ASSUMED SMALL RELATIVE TO TOTAL NUMBER RANGES

5014

BASED ON 10000 (DIRECT KWH EQUIVALENT) BTU/CYCLE (5106) NO ADJUSTMENTS FOR SUPERIOR INSULATION. NO MULTIPLIER AVAILABLE BUT ASSUMED SMALL AT PRESENT. NORMAL USE RATE FROM (5103).

5015

FROM (5103). MULTIPLIER IS P OF HOUSEHOLDS (5107). TOTAL HOUSEHOLDS, (5102).

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FTN. 5016-5031

5016

QUICK WARM-UP TUBE SETS DRAW 30 WATTS WHEN OFF. ASSUMES DUTY CYCLE COMPLEMENTARY TO ACTUAL USE CYCLE (5108). SOLID STATE SETS ARE MAKING THIS FEATURE OBSOLETE. NO MULTIPLIER AVAILABLE AT PRESENT.

5017

FROM (5103). DISTRIBUTION OF DIFFERENT TYPES OF REFRIGERATION UNITS FROM (0007,50). TOTAL HOUSEHOLDS FROM (5102). P WITH REFRIGERATOR, (5107).

5018

FROM (5103). ASSUMES 50PC ARE NO FROST UNITS. TOTAL NUMBER FROM (5102).

5019

FROM (5101,55). REF. (5117) GIVES ESTIMATE FOR NO. GAS POST LIGHTS AT END OF 1972).

5020

BASED ON 950 KWH OF INCANDESCENT LIGHTING/DWELLING-YR (5104) THE BTU MEASURE FOR FLUORESCENT LIGHTING ASSUMES 55 KWH/DWELLING-YR FOR ONE 30 WATT LAMP USED 5 HR/DAY. MULTIPLIER IS TOTAL OCCUPIED UNITS (5102).

5021

FROM (5103).MULTIPLIER P IN 1969 FROM (0007).TOTAL HOUSEHOLDS 1969, 1970 FROM (0018).

5022

FROM (5103).MULTIPLIER ASSUMES 5P OF SINGLE FAMILY HOMES HAVE ATTIC FAN.NUMBER HOMES FROM (5102).

5023

FROM (5103).MULTIPLIER ASSUMES 90P OF ALL OCCUPIED UNITS WITH WARM AIR HEAT USE A FAN. NUMBER SUCH UNITS FROM (5102,1-288)

5024

FROM (5103).MULTIPLIER ASSUMES 50P OF HOMES WITH NO A/C USE A ROLL-ABOUT FAN. NUMBER A/C AND TOTAL UNITS FROM (5102,1-235)

5025

FROM (5103).MULTIPLIER ASSUMES 90P OF ALL RURAL HOMES USE A WATER PUMP. NUMBER RURAL HOMES FROM (5102,1-286)

5026

FROM (5103).MULTIPLIER ASSUMES 20 P OF ALL PHONOS ARE RADIO-PHONO COMBINATION. PERCENT HOMES WITH PHONOS FROM (5107). TOTAL HOUSEHOLDS FROM (5102).

5027

FROM (0002).BTU/BBL CONVERTED FROM (0005).

5028

FROM (0002). BTU/BBL CONVERTED FROM (0005). 0.218 P TAKEN AS SULFUR CONTENT OF NUMBER 2 FUEL OIL. BASED ON WEIGHTED AVERAGE OF SULFUR CONTENT IN FIVE REGIONS OF U.S. DERIVED FROM (5109,7) AND (5118,38).

5029

FROM (0002). 1031 BTU/CF CONVERSION FROM (0005).

5030

FROM (0002). 4.011BTU/BBL CONVERTED FROM (0005). ASSUMES AVERAGE SULFUR CONTENT OF 12 GRAINS/100 CF LPG. 15 GRAINS/100 CF IS REGULATION BY (5110). ASTM ALSO SETS 10 GRAINS/100 CF MAXIMUM FOR HD-5, A HIGH QUALITY PROPANE, INDICATING THAT ORDINARY LPG IS SOMEWHERE BETWEEN 10 AND 15 GRAINS/100 CF. SEE (5111).

5031

1031 BTU/CF CONVERTED FROM (0005). ASSUMES SAME EMISSION FACTORS AS FOR SPACE HEAT, EXCEPT FOR A 10P INCREASE IN NOX RATE, FROM (0008,A-1) 4.011 BTU/BBL CONVERTED FOR LPG ALSO FROM (0005). SPACE HEAT FACTORS FROM (0002)

5032

FROM (0002). BTU/BBL CONVERTED FROM (0005). OIL WATER HEAT AND SPACE HEAT ARE FROM SAME FURNACE. THE SULFUR CONTENT OF FUEL OIL IS TAKEN AS 0.218 PC BASED ON A WEIGHTED AVERAGE OF SULFUR CONTENTS IN THE 5 U.S. REGIONS, DERIVED FROM (5109,7) AND (5118,38).

5033

EMISSION FACTORS FOR SPACE HEAT FROM (0002). THE FOLLOWING CORRECTION FACTORS FOR OTHER RESIDENTIAL USES ARE INFERRED FROM (0008,A-1)

	PART	NOX	SOX	HC	CO	ALDEHYDES
RANGE	1.0	0.6	1.0	1.0	1.0	1.0
DRYER	1.0	0.5	1.0	1.0	1.0	1.0
WATER HEATING	1.0	1.1	1.0	1.0	1.0	1.0

UNIT CONVERSIONS FOR NATURAL GAS, LPG FROM (0005). SULFUR CONTENT FOR LPG FROM ASTM STANDARDS (5110), AND (5111). GAS CENTRAL A/C USES ABSORPTION CYCLE, WITH NO MOVING PARTS EXCEPT FOR A SMALL FAN. GAS IS FIRED UNDER A VESSEL TO HEAT A LIQUID. IT IS ASSUMED THAT GAS A/C EMISSIONS ARE SAME AS FOR WATER HEAT.

5034

ASSUMES SOX EMISSIONS SAME AS SPACE HEAT FACTOR FROM (0002). NO FACTORS AVAILABLE FOR OTHER POLLUTANTS.

5035

EMISSION FACTORS, ESTIMATED DUTY CYCLE (50 HR/YEAR) FROM (5115,15FF). BTU PER UNIT-YR CALCULATED FROM 0.043P SULFUR IN GASOLINE PRODUCING 26 GR/UNIT-YR SO2, IN 4-STROKE ENGINES. ASSUME THIS FIGURE (CORRESPONDING TO 12 GALLONS GAS/YEAR) REPRESENTS ALL MOWERS, SINCE 2-STROKE ENGINES ARE ONLY 7P OF TOTAL. EMISSION RATES GIVEN IN (5115,15FF) FOR 4-STROKE AND 2-STROKE ENGINES WERE WEIGHTED BY NUMBER EACH TYPE IN USE TO GET AVERAGE VALUES. 0.67 GR/CU CM GASOLINE FROM (5116,F3). 5.248E+06 BTU/BBL GASOLINE FROM (0005). TOTAL NUMBER IN USE ESTIMATED AT ONE PER SINGLE FAMILY RESIDENCE. NO. RESIDENCES, FROM (5102), WAS 42.1 MM IN 1970.

NOTE- ELECTRICAL ENERGY CONSUMPTION GIVEN IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE EFFICIENCY OF POWER PLANT ENERGY PRODUCTION.

VIII. COMMERCIAL END USE

A. Introduction

The environmental impacts and energy use in the uncontrolled commercial end use sector are given in Table 28. Eighteen separate categories of end use have been identified. It is estimated that these categories cover more than 95 percent of all commercial energy use.

No individual category use rates exist in the literature and hence the measures assigned are based on the simplest practical definition of energy use.

By estimating the average floor area per employee, it is possible to compute, for instance, the total design lighting, cooling, and heating loads in the commercial sector. Detailed employment statistics are published by the Bureau of Labor. Design lighting, cooling, heating, and total occupancy criteria for all types of commercial buildings are available from the Electric Energy Association. Thus, the expedient measure of energy use for electric lighting is "square foot-year," and energy (Column 28) is expressed as "Btu/square foot-year." The multiplier is then the computed area of commercial space using electric lighting, namely all commercial area.

Several assumptions must be made before the rather broad commercial sector data available can be broken apart into desirable components. For example, one assumption involves the average floor area per employee. Special pain has been taken in the footnotes to state clearly what these assumptions are. Some of the work in the commercial sector is new, and probably unavailable from any source heretofore.

B. Impact Data Table and Footnotes

END USE SECTOR: COMMERCIAL

ROW	SUB-SECTOR	END USE	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS: PO_4	4 DISSOLVED SOLIDS: NO_3	5 DISSOLVED SOLIDS: OTHER	6 DISSOLVED SOLIDS: TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOT/L COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/MEAS)	13 AIR POLLUTANTS: PARTIC-ULATES	14 NO_x	15 SO_x	16 HYDROCARBONS
			WATER POLLUTANTS (TONS/MEASURE, EX. COL. 12)															
1		SPACE HEAT - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.22-00 3 5000	1.21-00 3 5000	7.15-00 3 5000	9.19-01
2		SPACE HEAT - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.45-00 3 5000	1.32-00 3 5000	1.36-00 3 5000	9.65-01
3		SPACE HEAT - DIST.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.38-00 3 5000	1.54-00 3 5000	2.00-00 3 5000	2.19-01
4		SPACE HEAT - BRIQ.	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 0007	0.00+00 3 0007	0000	0000	0000	1.00-00 3 5000	6.12-01 3 5000	2.28-00 3 5000	2.00-01
5		SPACE HEAT - COAL	0000	0000	0000	0000	0000	0000	0000	0.00+00 3 0007	0.00+00 3 0007	0000	0000	0000	1.18-00 3 5000	3.30-01 3 5000	3.[illegible]-00 3 5000	1.00-01
6		WATER HEAT - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	8.30-00 4 5000	5.16-00 4 5000	2.90-10 4 5000	4.65-00
7		WATER HEAT - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.01-00 4 5000	6.00-00 4 5000	5.7[illegible]-00 4 5000	4.00-00
8		WATER HEAT - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
9		COOKING - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	5.12-00 4 5000	1.01-07 4 5000	1.05-00 4 5000	1.44-00
10		COOKING - LPG	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	3.00-00 4 5000	1.10-07 4 5000	2.03-00 4 5000	1.40-00
11		COOKING - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
12		REFRIG. AND FREEZING - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
13		ELECTRIC A/C - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
14		GAS A/C - NAT. GAS	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
15		GAS A/C - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	2.06-07 5 5000	1.55-00 5 5000	8.23-00 5 5000	1.10-07
16		INDOOR LIGHTS - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
17		STREET LIGHTS - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
18		MISC. APPLIANCES - ELECT.	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
19		PAVEMENT OR ASPHALT	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	
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NOTE: ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE FOSSIL FUEL EQUIVALENT OF ELECTRICITY.

HITTMAN

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/MEASURE)							SOLIDS (TONS/MEAS)	LAND (ACRES)	OCCUPATIONAL HEALTH			POTENTIAL LARGE SCALE DISASTER	FUEL	MEASURE	ENERGY (BTU/MEAS)	MULTIPLIER	MULTIPLIER YEAR	ROW
PARTICULATES	NO_2	SO_2	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL			DEATHS MEAS	INJURIES MEAS	MAN-DAYS LOST/MEAS							
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	N. GAS	MF-YR	[illegible]	[illegible]	1970	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	LPG	MF-YR	[illegible]	[illegible]	1970	2
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	DISTILLATE	MF-YR	[illegible]	[illegible]	1970	3
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	RESIDUAL	MF-YR	[illegible]	[illegible]	1970	4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	COAL	MF-YR	[illegible]	[illegible]	1970	5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	N. GAS	GAL	[illegible]	[illegible]	1970	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	LPG	GAL	[illegible]	[illegible]	1970	7
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	GOL	[illegible]	[illegible]	1970	8
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	N. GAS	MCAL	[illegible]	[illegible]	1970	9
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	LPG	MCAL	[illegible]	[illegible]	1970	10
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	MCAL	[illegible]	[illegible]	1970	11
0000	0000	0000	0000	0000	0000	0000	[illegible]	0000	0000	0000	0000	0000	ELECTRICITY	CF-YR	[illegible]	[illegible]	1970	12
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	MF-YR	[illegible]	[illegible]	1970	13
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	N. GAS	MF-YR	[illegible]	[illegible]	1970	14
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	MF-YR	[illegible]	[illegible]	1970	15
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	MF-YR	[illegible]	[illegible]	1970	16
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	LAMP-YR	[illegible]	[illegible]	1970	17
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ELECTRICITY	MF-YR	[illegible]	[illegible]	1970	18
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	ASPHALT	BBL	[illegible]	[illegible]	1970	19
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TABLE 28. ENVIRONMENTAL IMPACTS AND EFFICIENCY OF COMMERCIAL ENERGY USE

5501

FROM (5501), INSTALLED RECEPTACLES PROVIDE 2.0 WATTS/SF IN COMMERCIAL BUILDINGS. ASSUME 10P IS USED FOR MISCELLANEOUS APPLIANCES NOT INCLUDING OTHER USES COVERED IN THIS TABLE, DURING BUILDING USE. (5502) SHOWS COMMERCIAL BUILDINGS OPEN FOR BUSINESS 59.5 HR/WK, PLUS 10 HR/WK AT 1/3 LOAD, OR TOTAL 63 HR/WK OPERATION. FROM (5503), IN 1970 THERE WERE 46.1 MM EMPLOYEES IN COMMERCIAL AREA. 350 SF/EMPLOYEE IS ASSUMED. SEE FOOTNOTE 5508 FOR JUSTIFICATION OF THIS SF/EMPLOYEE NUMBER.

5502

FROM (5501), DESIGN CRITERION FOR LIGHTING IS ABOUT 4-5 WATTS/SF. WE CONSERVATIVELY ASSUME 3.0 WATTS/SF FOR AVERAGE COMMERCIAL BUILDING. (5502) SHOWS DATA FOR MANY KINDS OF COMMERCIAL BUILDINGS OPEN FOR BUSINESS 59.5 HR/WK PLUS 10 HR/WK AT 1/3 POWER, OR TOTAL OF 63 HR/WK. FROM (5503), IN 1970 THERE WERE 46.1 MM COMMERCIAL EMPLOYEES. ASSUME 350 SF/EMPLOYEE.

5503

FROM (0007,77-78). THERE IS AN AVERAGE 480 KWH/CF-YR REFRIGERATION VOLUME IN COMMERCIAL BUILDINGS. WE ASSUME 480 KWH/CF-YR FOR FREEZER VOLUME, TOO, SINCE RESIDENTIAL DATA FROM (5504) SHOW REFRIGERATORS, FREEZERS USE SAME KWH/CF-YR. FROM (0007) IN 1970 THERE WERE 158 MMCF TOTAL VOLUME REFRIGERATOR AND FREEZER IN COMMERCIAL BUILDINGS.

5504

FROM (5501), DESIGN SPECIFICATION FOR COMMERCIAL FLOOR SPACE IS 250 SF/TON CAPACITY OR 48 BTUH/SF. (5502) SAYS IN 1959 REFRIGERATOR AIR COOLING EQUIPMENT OPERATED ABOUT 865 EQUIVALENT FULL LOAD HRS/YR. (0007) SAYS 1000 HRS/YR IS NOMINAL. WE ASSUME 1000 EQUIVALENT FULL LOAD HRS/YR FOR 1970. (5502,1021) SAYS A DRY CONDENSING CYCLE A/C WITH 90 DEGREE F CONDENSOR AND 40 DEGREE F EVAPORATOR REQUIRES ABOUT 0.8 BHP/TON RATING. THIS INDICATES A COEFFICIENT OF PERFORMANCE OF 3.3 FOR REFRIG. CYCLE PART OF SYSTEM. FROM (5502,1021), REFRIGERATION IS USUALLY LARGEST POWER USER IN COMMERCIAL A/C SYSTEMS. TO ACCOUNT FOR AUXILIARY EQUIPMENT LIKE FANS, PUMPS, WE ADD ANOTHER 90P TO ENERGY USE RATE FOR REFRIGERATION CYCLE ALONE. FROM (0007) ABOUT 70 P COMMERCIAL AREA HAD A/C IN 1970, AND 13 P OF THAT WAS GAS A/C, THE REST ELECTRIC. TOTAL FLOOR AREA ASSUMES 350 SF/EMPLOYEE 46.1 MM EMPLOYEES FROM (5503). FOR GAS UNITS WE ASSUME A COEFFICIENT OF PERFORMANCE OF 1.65, AND ADD 90/2=45P TO TOTAL IN FORM OF ELECTRICITY FOR AUXILIARY EQUIPMENT.

5505

ASSUME TOTAL NUMBER OF MEALS IN 1970 WAS 200 MM PEOPLE AT 3 MEALS/DAY OR 220 MMK MEALS. (0007) ESTIMATES 17.5 P OF ALL MEALS WERE PREPARED COMMERCIALLY IN 1968, AND 12 P OF THOSE WITH ELECTRICITY--GAS COOKING IS 1/2 AS EFFICIENT AS ELECTRIC. FROM (0007) GROWTH RATES WE ESTIMATE 125E12 BTU GAS AND 8.55E12 EQUIVALENT BTU ELECTRICITY USED IN 1970. ASSUME RATIO LPG/LPG+N.GAS IN ALL COMMERCIAL USES (10.6/246.8=4.3P) HOLDS FOR COOKING. FINAL ELECTRICAL RATE CONVERTED BY (3X3413) BTU/KWH.

5506

FROM (0007) 580E09 GALLONS WATER HEATED COMMERCIALLY, 1968. FROM (0007) GROWTH RATE WE GET 600E09 FOR 1970. FROM (0007) 70P WATER IS HEATED BY GAS, 20P ELECTRIC, 10P COINCIDENTAL WITH SPACE HEAT (WE INCLUDE THIS 10P WITH SPACE HEAT). ALSO FROM (0007) ASSUME 92P EFFICIENCY FOR ELECTRICITY AND 64P EFFICIENCY FOR GAS, AT 80 DEGREES F TEMPERATURE RISE AND 8.345 LB/GAL WATER. NEGLECT STANDING LOSSES. ASSUME OVERALL

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FTN. 5507-5509

COMMERCIAL RATIO LPG/LPG+N.GAS (=4.3P) HOLDS FOR WATER HEAT.

5507

(5505,31) SAYS 11.18E09 KWH USED FOR STREET LIGHTING, 1970. FROM (5506,31), MODERATE SIZE STREET LAMP IS 4000 LUMENS AND 300 WATTS. ASSUME 11HR/DAY SCHEDULE. AS A CHECK,THERE WERE 451 M MILES CITY STREETS IN 1969 (5507,58). 9.2MM LAMPS OVER 451 M MILES MEANS ABOUT 250 FT BETWEEN LAMPS WHICH IS REASONABLE.

5508

ASSUME REMAINDER OF FUEL ENERGY NOT OTHERWISE IDENTIFIED GOES INTO SPACE HEAT. APPROXIMATE BURNER EFFICIENCIES DETERMINE FRACTIONS OF TOTAL FLOOR AREA HEATED BY DIFFERENT FUEL INPUTS. TOTAL FLOOR AREA ESTIMATE IS 350 SF/EMPLOYEE. 46.1 MM WORKERS FROM (5503). (0007,18) GIVES THESE BURNER EFFICIENCIES FOR COMMERCIAL SPACE HEATING: COAL- 70P N.GAS- 77P LPG- 77P OIL- 76P. WE ASSUME RESIDUAL AND DISTILLATE OIL SAME EFFICIENCY. TOTAL NATURAL GAS FOR COMMERCIAL AND OTHER (INSTITUTION, MUNICIPAL) CATEGORIES= 2.44E+15 BTU . TOTAL RESIDUAL FUEL OIL (COMMERCIAL) =1.17E+15 BTU . TOTAL COAL = 4.27E+14 BTU (ASSUME ALL COMMERCIAL) LISTED UNDER RESIDENTIAL AND COMMERCIAL . TOTAL LPG FOR RESIDENTIAL AND COMMERCIAL = 7.228E+14 BTU . DISTILLATE FUEL OIL FOR RESIDENTIAL AND COMMERCIAL = 3.06E+15 BTU, FROM (C025,23/28). AMOUNTS IN MISCELLANEOUS CATEGORIES SMALL, EXCEPT FOR NATURAL GAS, ASSUMED TO BE FOR MUNICIPAL USE (INCLUDED). TOTAL RESIDENTIAL LPG= 6.17E+14 BTU, FROM TABLE 27 TOTAL DISTILLATE FOR RESIDENTIAL USE = 2.49E+15 BTU. SUBTRACTING ENERGY FOR OTHER COMMERCIAL USES LEAVES THESE AMOUNTS FOR SPACE HEAT NATURAL GAS- 1.86E+15 BTU; LPG- 8.3E+13 BTU; COAL- 4.27E+14 BTU, DISTILLATE- 5.70E+14 BTU, RESIDUAL- 1.17E+15 BTU. SOLVING,WE GET THE AREAS HEATED BY EACH FUEL, AND FINALLY THE BTU/SF-YR FOR EACH FUEL. AS A CHECK, (5501) GIVES NOMINAL DESIGN CRITERION OF 3.6 BTUH/CF VOLUME COMMERCIAL AREA. ASSUMING 2000 FULL LOAD HEATING HRS PER YEAR AND 45P SYSTEM EFFICIENCY, COMPARISON WITH 2.52E+05 BTU/SF-YR USE RATE FOR GAS INDICATES THAT THE AVERAGE CEILING HEIGHT MUST BE ABOUT 15.7 FEET, A REASONABLE NUMBER.

5509

SPACE HEAT FACTORS TAKEN FROM (0002). 1031 BTU/CF (DRY) NATURAL GAS, 4.01E+06 BTU/BBL LPG, 5.83E+06 BTU/BBL DISTILLATE OIL, 6.29E+06 BTU/BBL RESIDUAL OIL, 2.54E+07 BTU/TON ANTHRACITE, AND 2.42E+06 BTU/TON. BITUMINOUS COAL FROM (0005,38). 12 GRAINS SULFUR/100 CF LPG FROM (5511) AND (5512). 0.218 PC SULFUR IN NUMBER 2 FUEL OIL FROM (5513) AND (5518,38) BY AVERAGING FIVE REGIONAL VALUES; 1.73P SULFUR IN NO. 5 FUEL OIL FROM SAME REFERENCE. ANTHRACITE IS 27P OF COMMERCIAL COAL, REST BITUMINOUS, FROM (0025). FROM (5510), ANTHRACITE IS 12P ASH, 0.6P SULFUR; BITUMINOUS IS 10P ASH, 2.0P SULFUR. SOLID WASTE/MEASURE IS DERIVED FROM THE ASH CONTENTS OF THE COALS AND SPACE HEAT FACTORS IN (0002). PARTICULATE EMISSIONS ARE SUBTRACTED. FOLLOWING CORRECTION FACTORS APPLIED TO SPACE HEAT FACTORS (0002) GIVE EMISSIONS FOR OTHER USES, FROM (0008,A-1).

(GAS)	PART	SOX	CO	HC	NOX	ALDEHYDES
WATER HT	1.0	1.0	1.0	1.0	1.1	1.0
COOKING	1.0	1.0	1.0	1.0	0.6	1.0
AIR CONDITIONING	1.0	1.0	1.0	1.0	1.1	1.0

WE ASSUME AIR CONDITIONING EMISSIONS SIMILAR TO WATER HEAT.

5510 199
BTU/BBL ASPHALT AND ROAD OIL FROM (0005,38). TOTAL NUMBER BTU 299
FROM (0025,28). 399

NOTE- ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE EFFICIENCY OF POWER PLANT ELECTRICITY PRODUCTION.

IX. INDUSTRIAL END USE

A. Introduction

The industrial sector has been approached on an industry basis, staying within the general definition of the industry that is consistent with its SIC (Standard Industrial Classification) code number. The industrial data are contained in Table 29 with six industries presented in the following order:

SIC 26	Paper and Allied Products
SIC 37	Transportation Equipment
SIC 32	Stone Clay, Glass and Concrete
SIC 28	Chemicals
SIC 20	Food and Kindred Products
SIC 33	Primary Metals

A seventh large industry, SIC 29 - Petroleum Refineries and Related Products, is contained implicitly within the oil tables. In descending order of energy consumption among all industries, the six industries evaluated are as follows:

1	SIC 33
2	SIC 28
3	SIC 32
4	SIC 26
5	SIC 20
6	SIC 37

Each of the industries has been broken down into subparts which, in effect, correspond to a specific end use. For example, Pulp and Paper Mills under SIC 26 is the first such industrial end use. A further breakdown of the end use is by the fuels consumed. Note however, that contrary to other end use tables, environmental impacts are not allocated to each fuel. The available data on industrial environmental impacts did not justify any attempt at disaggregating the level of data presented. The environmental usefulness of the industrial table is limited, therefore, since environmental impacts cannot be allocated to specific fuels except in a very approximate fashion.

The 1967 Census of Manufactures - Fuels and Electric Energy Consumed -, was used to determine the energy efficiencies of many of the industrial end uses. Certain assumptions are inherent in that use and should be noted.

- There are certain omissions in the data from this reference where consumption of certain fuels is withheld to avoid divulging individual company data. It is assumed that the omissions for any SIC category are small in comparison with the consumption of fuel types given.

- For industries in which the fuel efficiency is based on the 1967 data, the assumption is made that fuel mixes and efficiencies remain constant between 1967 and the specified multiplier year.

- Use of 1967 data fixes the production processes and fuel mixes of the industries involved to that year. General Reference 0007 - Patterns of Energy Consumption in the U.S., Stanford Research Institute, 1972 - can be used for information about trends in production processes that could affect fuel efficiencies and fuel mixes.

As a general caution the reader is urged to read the footnotes before using the industrial end-use data. The footnote will point out exactly which environmental impacts have been presented (energy-related, process-related or both). Difficulties in distinguishing the impacts together with the limited data available precluded rigorous separation of the industrial end-use environmental impacts. Figure 13 summarizes the emission data which appear in the tables.

Industry Classification	Process Related Emissions Included With Energy Use-Related Emissions	
	Water Emissions	Air Emissions
Pulp and Paper Mills	Yes	Yes*
Paper Products Mfr.	Yes	No
Motor Vehicles	No	No
Motor Vehicle Parts	No	No
Glass Products	Yes	Yes*
Clay Products	No	Yes*
Cement and Related	Yes	Yes*
Stone and Related	Yes	Yes*
Chemicals, Inorganic**	Yes	Yes*
Chemicals, Organic	Yes	Yes*
Meat and Dairy Products	Yes	No
Bakery Sugar Confectionary	Yes	No
Beverage, Can, Cured & Frozen**	Yes	Yes*
Grain Mill & Misc. Food & Kindred	Yes	Yes*
Iron & Steel Making	No	No
Iron & Steel Castings	No	No
Primary Aluminum	No	No
Primary Copper	No	No
Primary Zinc	No	No

* Table entry includes both energy and process related emissions, however, these emissions are disaggregated in the related footnote.

** Solid waste table entry includes process related impact.

Figure 13. Basis for Industrial End-Use Emission Data

B. Impact Data Tables and Footnotes

ROW	SIC-MCM	END USE SECTOR / INDUSTRIAL (1 OF 3) / END USE	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/MEAS)	13 AIR POLLUTANTS PARTIC-ULATES	14 NO_x	15 SO_x	16 HYDROCARBONS
		WATER POLLUTANTS (TONS/MEASURE, EX. COL. 12)																
1	SIC30	PAPER & ALLIED PRODUCTS																
2	PPMIL	PULP AND PAPER MILLS	0000	0000	0000	0000	0000	0.75-02 3 0002	2.25-02 3 0002	0000	3.76-01 3 0502	2.60-02 3 0002	6.17-02 3 0005	0000	4.17-02 3 0502	2.84-03 3 0301	1.69-02 3 0-03	7.0[illegible]
3		GAS																
4		COAL																
5		RESID																
6		DSTL																
7		ELECT																
8	PPMFG	PAPER PRODUCTS MFG	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0.00-00 2 0007	0000	1.03-01 2 0504	1.30-06 2 0314	1.75-04 2 0314	0.30[illegible]
9		GAS																
10		COAL																
11		RESID																
12		DSTL																
13		ELECT																
14																		
15	SIC37	TRANSPORTATION EQUIPMENT																
16	MOVEH	MOTOR VEHICLES	0000	0000	0000	0000	0000	0004	1.63-04 1 0703	5.23-03 4 0703	0000	1.00-04 3 0703	3.53-04 4 0703	0000	4.76-03 3 0702	1.53-03 3 0702	3.53-03 3 0702	1.33[illegible]
17		COAL																
18		DSTL																
19		RESID																
20		GAS																
21		ELECT																
22	PARTS	PARTS	0000	0000	0000	0000	4.00-03 4 0704	0000	2.33-04 4 0704	8.50-03 4 0704	0000	1.70-03 4 0704	0000	0000	2.53-03 4 0702	8.12-04 4 0702	2.16-03 4 0702	0.30[illegible]
23		COAL																
24		DSTL																
25		RESID																
26		GAS																
27		ELECT																
28																		
29	SIC32	STONE, CLAY, GLASS & CONCRETE																
30	GLASS	GLASS PRODUCTS	0000	0000	3.20-04 5 0320	3 0007	0000	2.31-02 5 0320	1.35-03 5 0320	1.25-03 5 0320	2.57-02	1.20-03 5 0320	0000	0000	1.13-03 5 0320	8.01-04 4 0320	4.19-03 4 0320	
31		COAL																
32		RESID																
33		DSTL																
34		GAS																
35		ELECT																
36	CLAY	CLAY PRODUCTS	0000	0000	4 0007	4 0007	0000	0000	0000	0000		0000	0000	0000	1.00-03 4 0304	3.50-04 4 0303	3 0307	
37		COAL																
38		RESID																
39		DSTL																
40		GAS																
41		ELECT																
42	CEMNT	CEMENT AND RELATED	0000	1.57-05 4 0330	3 0007	3 0007	3.20-05 4 0330	7.[illegible]-05 4 0311	2.01-05 4 0330	0000	1.57-04	4.50-01 4 0330	1.20-07 4 0330	0000	6.91-03 4 0311	1.00-04 4 0312	7.10-04 4 0313	1.70[illegible]
43		COAL																
44		RESID																
45		DSTL																
46		GAS																
47		ELECT																
48	STONE	STONE AND RELATED	0000	0000	3 0007	3 0007	0000	2.00-02 5 0333	3.61-04 5 0330	0000	2.10-02	3.42-04 5 0330	1.01-04 5 0330	0000	1.70-02 2 0310	3.31-04 4 0320	1.06-04 4 0321	0.00[illegible]
49		COAL																
50		COKE																

NOTE: ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE FOSSIL FUEL EQUIVALENT OF ELECTRICITY.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS / MEASURE)									OCCUPATIONAL HEALTH									
PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/MEAS.)	LAND (ACRES)	DEATHS MEAS	INJURIES MEAS	MAN-DAYS LOST/MEAS	POTENTIAL LARGE SCALE DISASTER	FUEL	MEASURE	ENERGY (BTU/MEAS.)	MULTIPLIER	MULTIPLIER YEAR	ROW
																		1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	AGGREGATE	TON	[illegible]	[illegible]	1971	2
													NATURAL GAS	TON	[illegible]	[illegible]	1971	3
													COAL	TON	[illegible]	[illegible]	1971	4
													RESIDUAL	TON	[illegible]	[illegible]	1971	5
													DISTILLATE	TON	[illegible]	[illegible]	1971	6
													ELECTRICITY	TON	[illegible]	[illegible]	1971	7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	[illegible]	0000	0000	[illegible]	AGGREGATE	TON	[illegible]	[illegible]	1971	8
													NATURAL GAS	TON	[illegible]	[illegible]	1971	9
													COAL	TON	[illegible]	[illegible]	1971	10
													RESIDUAL	TON	[illegible]	[illegible]	1971	11
													DISTILLATE	TON	[illegible]	[illegible]	1971	12
													ELECTRICITY	TON	[illegible]	[illegible]	1971	13
																		14
																		15
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	0000	0000	0000	0000	AGGREGATE	UNIT	[illegible]	[illegible]	1971	16
													COAL	UNIT	[illegible]	[illegible]	1971	17
													DISTILLATE	UNIT	[illegible]	[illegible]	1971	18
													RESIDUAL	UNIT	[illegible]	[illegible]	1971	19
													NATURAL GAS	UNIT	[illegible]	[illegible]	1971	20
													ELECTRICITY	UNIT	[illegible]	[illegible]	1971	21
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	[illegible]	0000	0000	0000	0000	AGGREGATE	TON	[illegible]	[illegible]	1971	22
													COAL	TON	[illegible]	[illegible]	1971	23
													DISTILLATE	TON	[illegible]	[illegible]	1971	24
													RESIDUAL	TON	[illegible]	[illegible]	1971	25
													NATURAL GAS	TON	[illegible]	[illegible]	1971	26
													ELECTRICITY	TON	[illegible]	[illegible]	1971	27
																		28
																		29
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	AGGREGATE	TON	[illegible]	[illegible]	1971	30
													COAL	TON	[illegible]	[illegible]	[illegible]	31
													RESIDUAL	TON	[illegible]	[illegible]	1971	32
													DISTILLATE	TON	[illegible]	[illegible]	1971	33
													NATURAL GAS	TON	[illegible]	[illegible]	1971	34
													ELECTRICITY	TON	[illegible]	[illegible]	1971	35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	AGGREGATE	TON	[illegible]	[illegible]	1971	36
													COAL	TON	[illegible]	[illegible]	1971	37
													RESIDUAL	TON	[illegible]	[illegible]	1971	38
													DISTILLATE	TON	[illegible]	[illegible]	1971	39
													NATURAL GAS	TON	[illegible]	[illegible]	1971	40
													ELECTRICITY	TON	[illegible]	[illegible]	1971	41
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	AGGREGATE	TON	[illegible]	[illegible]	1970	42
													COAL	TON	[illegible]	[illegible]	1970	43
													RESIDUAL	TON	[illegible]	[illegible]	1970	44
													DISTILLATE	TON	[illegible]	[illegible]	1970	45
													NATURAL GAS	TON	[illegible]	[illegible]	1970	46
													ELECTRICITY	TON	[illegible]	[illegible]	1970	47
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0000	0000	0000	0000	0000	0000	AGGREGATE	TON	[illegible]	[illegible]	1970	48
													COAL	TON	[illegible]	[illegible]	1970	49
													COKE	TON	[illegible]	[illegible]	1970	50

TABLE 29. ENVIRONMENTAL IMPACTS AND EFFICIENCY OF INDUSTRIAL ENERGY USE (PART 1 OF 3)

UNCONTROLLED

END USE SECTOR

INDUSTRIAL (2 OF 2)

ROW	MNE-MON.	END USE	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/MEAS.)	13 PARTIC-ULATES	14 NO_x	15 SO_x
			WATER POLLUTANTS (TONS/MEASURE, EX. COL 12)												AIR POLL		
1	SICSU	CHEMICALS															
2	INOCH	INORGANIC	1.70-02 6 0108	6.04-08 6 0108	8.04-03 6 0106	0000	8.06-01 6 0106	1.06-01 6 0106	5.60-01 6 0106	3.17-06 6 0107	5.12-01 6	9.21-05 6 0109	5.67-01 6 0106	0000	2.20-02 6 0116	8.06-06 6 0116	1.00-02 6 0116
3		COAL															
4		COKE															
5		RESID															
6		DSTL															
7		GAS															
8		ELECT															
9	ORGCH	ORGANIC	2.00-02 5 0127	0000	5.00-05 5 0126	0000	0000	2.55-03 5 0126	1.66-02 6 0126	2.50-02 6 0132	6.81-04 5	1.06-05 6 0130	5.10-05 6 0131	0000	3.00-01 6 0120	1.61-03 6 0122	4.01-02 6 0128
10		COAL															
11		COKE															
12		RESID															
13		DSTL															
14		GAS															
15		ELECT															
16	SICSB	FOOD AND KINDRED PRODUCTS															
17	MTDAI	MEAT AND DAIRY PRODUCTS	3 0007	0000	6.00-06 6 0403	6.75-07 6 0403	4.06-04 6 0403	4.16-06 6 0403	5.60-06 6 0403	1.80-04 6 0403	1.17-03 5	4.06-03 3 0403	4.50-03 3 0403	0000	1.16-03 3 0402	1.16-04 3 0402	7.80-06 3 0402
18		COAL															
19		DSTL															
20		RESID															
21		GAS															
22		ELECT															
23	BAKER	BAKERY, SUGAR, CONFECTIONARY	3 0007	5.57-03 6 0407	2.50-03 6 0407	4.35-03 6 0407	2.60-01 6 0407	2.5-01 6 0410	5.80-01 6 0407	0000	8.67-01 5	3.20-03 6 0407	2.23-01 6 0407	0000	2.90-01 3 0406	4.62-04 3 0406	2.65-06 3 0406
24		COAL															
25		COKE															
26		DSTL															
27		RESID															
28		GAS															
29		ELECT															
30	BEVER	BEVERAGE, CAN, CURED & FROZEN	0000	2.66-06 6 0411	1.67-03 5 0411	5.95-05 6 0411	0000	6.12-02 6 0411	7.62-04 3 0411	2.66-04 1 0411	6.22-02 6	5.1.-02 3 0411	3.20-02 3 0411	0000	5.56-03 3 0408	1.62-04 3 0408	1.66-03 3 0408
31		COAL															
32		DSTL															
33		RESID															
34		GAS															
35		ELECT															
36	GRAIN	GRAIN MILL & MISC. FOOD & KIND	0000	0000	0000	0000	7.60-02 5 0414	0001	0000	0000	0000	0000	0000	0000	7.62-02 3 0415	1.08-04 3 0412	6.67-06 3 0415
37		COAL															
38		DSTL															
39		RESID															
40		GAS															
41		ELECT															
42	SICSB	PRIMARY METALS															
43	IRSTL	IRON & STEEL MAKING	0000	0000	0000	0000	7.13-05 6 0411	0000	1.21-02 6 0411	6.16-04 6 0411	0000	0000	0000	0010	1.05-02 3 0005	4.56-02 5 0000	4.05-06 5 0000
44		COAL															
45		COKE															
46		DSTL															
47		RESID															
48		GAS															
49		ELECT															
50																	

OTE: ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE FOSSIL FUEL EQUIVALENT OF ELECTRICITY.

HITTMAN

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/MEASURE)								OCCUPATIONAL HEALTH									
[illegible]	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/MEAS.)	LAND (ACRES)	DEATHS MEAS	INJURIES MEAS	MAN-DAYS LOST/MEAS	POTENTIAL LARGE SCALE DISASTER	FUEL	MEASURE	ENERGY (BTU/MEAS.)	MULTIPLIER	MULTIPLIER YEAR	ROW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						1
													AGGREGATE	TON	1.00+07	1.71+00 0101	1970	2
													COAL	TON	0.00+00 0 0110	1.71+00 0101	1970	3
													COKE	TON	1.00+00 0 0110	1.71+00 0101	1970	4
													RESIDUAL	TON	1.78+00 0 0110	1.71+00 0101	1970	5
													DISTILLATE	TON	7.12+00 0 0110	1.71+00 0101	1970	6
													NATURAL GAS	TON	4.00+00 0 0110	1.71+00 0101	1970	7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ELECTRICITY	TON	0.00+00 0 0110	1.71+00 0101	1970	8
													AGGREGATE	TON	2.11+07	1.10+00 0100	1970	9
													COAL	TON	0.10+00 0 0110	1.00+00 0100	1970	10
													COKE	TON	1.70+04 0 0110	1.10+00 0100	1970	11
													RESIDUAL	TON	1.00+00 0 0110	1.10+00 0100	1970	12
													DISTILLATE	TON	0.00+00 0 0110	1.10+00 0100	19[illegible]	13
													NATURAL GAS	TON	1.27+07 0 0110	1.10+00 0100	1970	14
													ELECTRICITY	TON	0.00+00 0 0110	1.10+00 0100	1970	15
																		16
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	AGGREGATE	TON	2.00+00	0.00+07 0400	1970	17
													COAL	TON	0.00+00 0 0401	0.00+07 0400	1970	18
													DISTILLATE	TON	1.00+00 0 0401	0.00+07 0400	1970	19
													RESIDUAL	TON	1.00+00 0 0401	0.00+07 0400	1970	20
													NATURAL GAS	TON	1.00+00 0 0401	0.00+07 0400	1970	21
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ELECTRICITY	TON	0.00+00 0 0401	0.00+07 0400	1970	22
													AGGREGATE	TON	[illegible]	3.12+07 0404	1970	23
													COAL	TON	0.75+00 0 0405	3.12+07 0404	1970	24
													COKE	TON	0.00+00 0 0405	3.12+07 0404	1970	25
													DISTILLATE	TON	0.00+00 0 0405	3.12+07 0404	1970	26
													RESIDUAL	TON	0.00+00 0 0405	3.12+07 0404	1970	27
													NATURAL GAS	TON	0.00+00 0 0405	3.12+07 0404	1970	28
													ELECTRICITY	TON	0.00+00 0 0405	3.12+07 0404	1970	29
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	AGGREGATE	TON	4.00+00	4.03+07 0400	1970	30
													COAL	TON	7.00+00 0 0406	4.03+07 0400	1970	31
													DISTILLATE	TON	0.00+00 0 0406	4.03+07 0400	1970	32
													RESIDUAL	TON	0.00+00 0 0406	4.03+07 0400	1970	33
													NATURAL GAS	TON	1.72+00 0 0406	4.03+07 0400	1970	34
													ELECTRICITY	TON	1.00+00 0 0406	4.03+07 0400	1970	35
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	AGGREGATE	TON	0.45+00	2.17+00 0412	1970	36
													COAL	TON	2.55+00 0 0406	2.17+00 0412	1970	37
													DISTILLATE	TON	0.00+00 0 0406	2.17+00 0412	1970	38
													RESIDUAL	TON	4.71+00 0 0406	2.17+00 0412	1970	39
													NATURAL GAS	TON	0.00+00 0 0406	2.17+00 0412	1970	40
													ELECTRICITY	TON	0.00+00 0 0406	2.17+00 0412	1970	41
																		42
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	AGGREGATE	TON	2.22+07 1 0000	1.22+00 0001	1972	43
													COAL	TON	0.00+00 1 0000	1.22+00 0001	1972	44
													COKE	TON	1.00+07 1 0000	1.22+00 0000	1972	45
													DISTILLATE	TON	0.00+00 0 0000	1.22+00 0000	1972	46
													RESIDUAL	TON	1.14+00 0 0000	1.22+00 0000	1972	47
													NATURAL GAS	TON	0.00+00 1 0000	1.22+00 0000	1972	48
													ELECTRICITY	TON	0.00+00 1 0000	1.22+00 0000	1972	49
																		50

TABLE 29. ENVIRONMENTAL IMPACTS AND EFFICIENCY OF INDUSTRIAL ENERGY USE (PART 2 OF 3)

Preceding page blank

INDUSTRIAL

END USE SECTOR

SHEET 3 OF 3

ROW	MINE MON.	END USE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			WATER POLLUTANTS (TONS/MEASURE, EX. COL. 12)												AIR POLLUTANTS			
					DISSOLVED SOLIDS													
			ACIDS	BASES	PO_4	NO_3	OTHER	TOTAL (DS)	SUSPENDED SOLIDS	ORGANICS	TOTAL COL'S 6,7,8	BOD	COD	THERMAL (BTU/MEAS.)	PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBON
1	CASTIG	IRON AND STEEL CASTINGS	0000	0000	3.0007	3.0007	0000	0000	1.37-02 3.6636	0000	0000	3.88-03 3.6632	2.29-02 3.6636	0000	3.45-04 3.6634	3.74-08 3.6634	3.6635	[illegible]
2		COAL																
3		COKE																
4		DSTL																
5		RESID																
6		GAS																
7		ELECT																
8	ALUM	PRIMARY ALUMINUM	0000	0000	0007	0007	5.00-03 3.6636	0000	5.00-03 3.6636	2.50-03 3.6636	[illegible]	1.82-04 3.6636	3.37-02 3.6636	0000	1.29-01 3.6636	2.6631	2.6633	[illegible]
9		COAL																
10		DSTL																
11		RESID																
12		PET. COKE																
13		GAS																
14		ELECT																
15	COPER	PRIMARY COPPER	0000	0000	0000	4.0007	0000	0000	1.74-02 3.6637	0000	0000	0000	2.18-03 3.6637	0000	2.02-04 3.6632	0000	6.25-02 3.6632	[illegible]
16		COAL																
17		COKE																
18		DSTL																
19		RESID																
20		GAS																
21		ELECT																
22	ZINC	PRIMARY ZINC	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1.00-02 3.6631	0000	2.02-02 3.6633	[illegible]
23		COAL																
24		COKE																
25		DSTL																
26		GAS																
27		ELECT																
28																		
29																		
30																		
31																		
32																		
33																		
34																		
35																		
36																		
37																		
38																		
39																		
40																		
41																		
42																		
43																		
44																		
45																		
46																		
47																		
48																		
49																		
50																		

NOTE: ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE FOSSIL FUEL EQUIVALENT OF ELECTRICITY.

HITTMAN

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/MEASURE)									OCCUPATIONAL HEALTH									
PARTIC-ULATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/MEAS.)	LAND (ACRES)	DEATHS MEAS	INJURIES MEAS	MAN-DAYS LOST/MEAS	POTENTIAL LARGE SCALE DISASTER	FUEL	MEASURE	ENERGY (BTU/MEAS.)	MULTIPLIER	MULTIPLIER YEAR	ROW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	AGGREGATE	TON	[illegible]	[illegible]	[illegible]	1
													COAL	TON	[illegible]	[illegible]	[illegible]	2
													COKE	TON	[illegible]	[illegible]	[illegible]	3
													DISTILLATE	TON	[illegible]	[illegible]	[illegible]	4
													RESIDUAL	TON	[illegible]	[illegible]	[illegible]	5
													NATURAL GAS	TON	[illegible]	[illegible]	[illegible]	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ELECTRICITY	TON	[illegible]	[illegible]	[illegible]	7
													AGGREGATE	TON	[illegible]	[illegible]	[illegible]	8
													COAL	TON	[illegible]	[illegible]	[illegible]	9
													DISTILLATE	TON	[illegible]	[illegible]	[illegible]	10
													RESIDUAL	TON	[illegible]	[illegible]	[illegible]	11
													PETROLEUM COKE	TON	[illegible]	[illegible]	[illegible]	12
													NATURAL GAS	TON	[illegible]	[illegible]	[illegible]	13
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ELECTRICITY	TON	[illegible]	[illegible]	[illegible]	14
													AGGREGATE	TON	[illegible]	[illegible]	[illegible]	15
													COAL	TON	[illegible]	[illegible]	[illegible]	16
													COKE	TON	[illegible]	[illegible]	[illegible]	17
													DISTILLATE	TON	[illegible]	[illegible]	[illegible]	18
													RESIDUAL	TON	[illegible]	[illegible]	[illegible]	19
													NATURAL GAS	TON	[illegible]	[illegible]	[illegible]	20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ELECTRICITY	TON	[illegible]	[illegible]	[illegible]	21
													AGGREGATE	TON	[illegible]	[illegible]	[illegible]	22
													COAL	TON	[illegible]	[illegible]	[illegible]	23
													COKE	TON	[illegible]	[illegible]	[illegible]	24
													DISTILLATE	TON	[illegible]	[illegible]	[illegible]	25
													NATURAL GAS	TON	[illegible]	[illegible]	[illegible]	26
													ELECTRICITY	TON	[illegible]	[illegible]	[illegible]	27
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TABLE 29. ENVIRONMENTAL IMPACTS AND EFFICIENCY OF INDUSTRIAL ENERGY USE (PART 3 OF 3)

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6100

INCLUDED UNDER ORGANIC CHEMICALS ARE ALL CHEMICALS REPORTED IN (6100) AND (0025,255/266). THESE CHEMICALS MAKE UP SIC 2815, SIC 2818, SIC 282, SIC 283, SIC 289, SIC 2879, SIC 2851, SIC 2861 AND MOST OF SIC 284. THE PERCENTAGE BREAKDOWN OF SELECTED ORGANIC CHEMICALS AS USED IS AS FOLLOWS- ACETIC ACID = 1.45, ACETONE = 0.68, ACRYLATES = 0.01, ADIPIC ACID = 0.44, CARBON BLACK = 1.24, DETERGENT = 1.15, ETHYL BENZENE AND STYRENE = 3.7, EXPLOSIVES = 0.90, BUTANOL = 0.20, BUTADIENE = 1.32, LD POLYETHYLENE = 1.8, PHTHALIC ANHYDRIDE = 0.73, PLASTICS = 6.65, PAINT = 1.02, PAINT AND VARNISH = 3.31, PRINTING INK = 1.02 POLYSTYRENE = 2.00, PHENOL = 0.77, PHENOLIC RESINS = 0.50, NYLON = 0.30, SYNTHETIC FIBERS = 0.60, SYNTHETIC RUBBER = 1.86, TEREPHTHATIC ACID = 0.55, UREA = 2.65, UREA & MELAMINE RESINS = 0.321.

6101

INCLUDED UNDER INORGANIC CHEMICALS ARE THOSE CHEMICALS REPORTED IN (6101), (6102) AND SELECTED MATERIAL FROM (0025). THESE CHEMICALS MAKE UP SIC 2812, SIC 2813, SIC 2816, SIC 2871, SIC 2872 AND PARTS OF SIC 284. WHERE VALUE OF TOTAL PRODUCTION ONLY IS GIVEN, THE AVERAGE VALUE OF REPORTED TONNAGE IS USED. THE PC BREAKDOWN OF PRODUCTION OF SELECTED CHEMICAL IS AS FOLLOWS- AMMONIA = 8.10, AL SULFATE = 0.74, CA CARBIDE = 0.46, CHLORINE = 8.30, FRIT = 0.58, HYDROCHLORIC ACID =1.18, HYDROFLOURIC ACID = 0.14, NITRIC ACID = 3.91, PHOSPHORIC ACID = 3.30, PHOSPHOROUS = 0.35, PHOSPHATE FERT. = 2.86, NITRATE FERT = 1.03, SODA ASH = 4.13, NA CHLORATE = 0.12, NA DICHROMATE = 0.09, NA METASILICATE =0.13, NA ORTHOSILICATE = 0.02, NA TRIPHOSPHATE = 0.71, SULFURIC ACID = 17.26

6102

ACID EFFLUENT FOR SELECTED INORGANIC CHEMICALS IS GIVEN BELOW - (6103,A). (WASHING AND RINSING EFFLUENT NOT INCLUDED) LB/TON

CHLORINE (DIAPHRAM AND MERCURY CELL)	42.07
PHOSPHORIC ACID (WET AND DRY PROCESS)	0.50
AL SULFATE (BAUXITE FEED AND CLAY FEED)	12.25
SODIUM METASILICATE	0.81
HYDROFLOURIC ACID	537.00

ACID EFFLUENT PER TON PRODUCT IS THE SUM FROM EACH SOURCE WEIGHTED BY PC OF PRODUCTION. SEE FOOTNOTE 6101

6103

EFFLUENT OF BASES FOR SELECTED INORGANIC CHEMICALS ARE GIVEN BELOW (6103,A) (EFFLUENT FOR WASHING AND SCRUBBING OPERATIONS ARE NOT INCLUDED)

	LB/TON
CHLORINE (DIAPHRAM AND MERCURY CELL)	43.50
SODIUM METASILICATE	10.00
SODA ASH	196.00
SODIUM CHLORATE	40.00

EFFLUENT OF BASES PER TON OF PRODUCT IS THE SUM OF EACH SOURCE WEIGHTED BY PC OF PRODUCTION. SEE FOOTNOTE 6101

6104

PHOSPHATE EFFLUENTS OCCUR IN MAKING PHOSPHORIC ACID PHOSPHOROUS AND SODIUM TRIPHOSPHATE. THE EFFLUENT IS AS FOLLOWS- (6103,A)

PHOSPHORIC ACID	22.50 LB/TON
PHOSPHOROUS	10.50 LB/TON
SODIUM TRIPOLY PHOSPHATE	11.00 LB/TON

TOTAL PHOSPHATE EFFLUENT IS THE SUM FROM EACH SOURCE WEIGHTED BY PERCENTAGE OF EACH SOURCE. SEE FOOTNOTE 6101.

6105

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FTN. 6106-6108

CLASSIFIED UNDER OTHER DISSOLVED SOLIDS IS A HOST OF DISSOLVED SOLIDS FROM EACH SOURCE. THE EFFLUENT FROM EACH SOURCE IS AS FOLLOWS (6103,A)-

	LB/TON
CHLORINE	520.50
PHOSPHOROUS	13.60
ALUMINUM SULFATE	454.50
SODA ASH	3314.40
SODIUM METASILICATE	6.10
HYDROFLOURIC ACID	7100.00
SODIUM CHLORATE	507.50
SODIUM DICHROMATE	200.00

TOTAL OTHER DISSOLVED SOLIDS IS THE SUM OF THE INDIVIDUAL SOURCES WEIGHTED BY THE PERCENTAGE OF PRODUCTION OF EACH SOURCE. SEE FOOTNOTE 6101

6106

EFFLUENT OF SUSPENDED SOLIDS IS AS FOLLOWS FOR VARIOUS INORGANIC CHEMICALS- (6103,A)

	LB/TON
CHLORINE	48.78
PHOSPHORIC ACID	4257.00
PHOSPHOROUS	137.00
SODA ASH	17.70
SODIUM METASILICATE	12.00
SODIUM ORTHOSILICATE	79.10
HYDROFLOURIC ACID	155.00

TOTAL SUSPENDED SOLIDS PER TON PRODUCT IS THE SUM OF EACH SOURCE WEIGHTED BY THE PC OF PRODUCTION OF EACH SOURCE. SEE FOOTNOTE 6101

6107

ORGANICS HAVE BEEN REPORTED FOR CHLORINE AND SODA ASH (6103,A)

	LB/TON
CHLORINE (CHLORINATED HYDROCARBON)	0.650
SODA ASH	0.003

ORGANICS PER TON OF PRODUCT IS THE SUM FROM EACH SOURCE WEIGHTED BY PC OF PRODUCTION OF EACH SOURCE. SEE FOOTNOTE 6101

6108

BOD PER MGD MAY BE ESTIMATED FROM TOTAL BOD (0016,E99), BOD AND FLOW FOR UNTREATED WATER (0016,103) AND TOTAL WASTEWATER FLOW (0016,98) FOR ALKALIES/CHLORINE, INDUSTRIAL INORGANICS AND FERTILIZERS AS FOLLOWS

TOTAL BOD (0016,99)	COMP.	BOD (LBS)
ALKALIES/CHLORINE	6	9237.0
INDUSTRIAL INORGANICS	10	53855.0
FERTILIZER	3	3918.0

UNTREATED (0016,103)	COMP.	(MGD)	BOD (LBS)
ALKALIES/CHLORINE	5	31.3	7697.0
INDUSTRIAL INORGANIC	6	189.3	32555.0
FERTILIZER	2	1.9	3612.0

TOTAL FLOW (0016,98)	COMP.	(MGD)	COMP.	(MGD)
ALKALIES/CHLORINE	6	18.6	9	39.8
INDUSTRIAL INORGANIC	10	28.4	13	201.8
FERTILIZER	3	17.5	8	69.1

TOTAL FLOW, MAY BE FOUND BY ASSUMING THE DIFFERENCE IN THE COMP. FROM TOTAL BOD AND THE COMP. FROM UNTREATED CAN BE ATTRIBUTED TO COMP. WITH TREATED WASTEWATER AND MULTIPLYING BY AVERAGE WASTEWATER FLOW. IN TURN THE BOD CAN BE ALLOCATED RESPECTIVELY.

	UNTREATED			TREATED		
	COMP.	(MGD)	BOD	COMP.	(MGD)	BOD
ALK/CHL	5	31.3	7697.0	1	3.10	1540.0
IND. INOR.	6	189.3	32555.0	4	11.36	21300.0
FERT.	2	1.9	3612.0	1	5.83	306.0

AVERAGE COD/MGD WEIGHTED BY NUMBER OF PLANTS = 742.78 LBS/MGD
AVERAGE WASTEWATER FLOW PER TON PRODUCT = 16.73 GAL/DAY (6104,1995)
COD/TON PRODUCT = 16.73 GPD/TON X -06MGD/GAL X 742.78 LBS/MGD
= 1.24-02 LB/TON OR 6.21-06 TON BOD

6109

COD MAY BE ESTIMATED FROM TOTAL COD (0016,8109), COD AND FLOW FOR SEPARATED WASTEWATER (0016,104) AND TOTAL WASTEWATER (0016,98) FOR ALKALIES/CHLORINE, INDUSTRIAL INORGANICS AND FERTILIZERS. USING THE PROCEDURE OF FOOTNOTE 6108, THE RESULTS ARE AS FOLLOWS:

	UNTREATED COMP.	(MGD)	COD	TREATED COMP.	(MGD)	COD
ALK/CHL	5	25.6	94950.0	0	0.0	0.0
INOR. INOR.	4	181.3	228000.0	4	11.36	42500.0
PERTS	2	1.9	4625.0	0	0.0	0.0

AVERAGE COD/MGD WEIGHTED BY NUMBER OF PLANTS = 2896.3 LBS/MGD
AVERAGE WASTEWATER FLOW PER TON PRODUCT = 16.73 GAL/DAY (6104,1995)
COD/TON PRODUCT = 16.73 GPD/TON X -06 MGD/GAL X 2896.3 LBS/MGD
= 4.85-02 LB/TON OR 2.42-05 TON

6110

ENERGY EFFICIENCY IS CALCULATED BY DIVIDING ENERGY OF FUEL TYPE USED IN 1967 (0041,SR4-18/SR4-19) BY PRODUCTION IN 1967 (6111,10) AND (0011,699). CONVERSION FACTORS FOR FUELS (0005,38). INCLUDED IN THE FUEL EFFICIENCY IS FEEDSTOCK CONSISTING OF 1.82+05 BTU COKE, 3.90+04 BTU COAL AND 1.65+06 BTU NATURAL GAS PER TON PRODUCT.

6111

THE GENERATION OF STEAM IS A MAJOR SOURCE OF FUEL CONSUMPTION AND AIR EMISSION. THE AMOUNT OF EMISSION DEPENDS UPON THE TYPE OF AND AMOUNT OF FUEL USED (0002,1-3/1-9). EMISSION FACTORS ARE GIVEN BY (0002,1-3/1-9), (A =14.4; S = 3.32 (6112,16) FOR COAL, S =1.0 FOR RESIDUAL (6118) S =0.224 FOR DISTILLATE (6113,7)) THE AMOUNT OF FUELS USED FOR STEAM GENERATION CAN BE CONSIDERED EQUAL TO THE AMOUNT OF FUEL FOR HEAT AND POWER, (6114) AND (0007,119). BASED ON THIS, TOTAL FUEL USED IS AS FOLLOWS (0041,SR4-18/SR4-19)- COAL = 5.62+06 TON, DISTILLATE = 1.75+06 BARREL, RESIDUAL = 4.01+06 BARREL, NATURAL GAS 4.49+05 MMCF. THE EMISSION FROM STEAM PRODUCTION FOR ONE TON OF PRODUCT (ALSO SEE FOOTNOTE 6110) IN TONS-

	PART	SOX	CO	HYDCARB	NOX	ALDHY	ORG
COAL	3.63-03	2.48-03	3.93-05	1.97-05	2.95-04	9.83-08	0.0
DIST	9.16-08	6.35-06	1.22-09	1.83-08	3.66-07	1.22-08	0.0
RESID	3.22-07	2.23-06	2.80-09	4.21-08	8.41-07	1.40-08	0.0
NA. GAS	2.82-05	9.41-07	6.27-07	6.27-05	1.96-04	4.71-06	1.1-05
TOTAL	3.71-03	2.49-03	3.99-05	8.25-05	4.92-04	4.83-06	1.1-05

TOTAL PARTICULATE EMISSION IS THE SUM OF EMISSION FROM STEAM GENERATION AND EMISSION FROM PROCESSES. PARTICULATE EMISSION FROM PROCESSES IS AS FOLLOWS-

HYDROFLUORIC ACID (0002,5-9)	20.00 LB/TON
PHOSPHORIC ACID (6105,3)	0.36 LB/TON
NITRATE FERTILIZER (0002,6-9)	10.00 LB/TON
PHOSPHATE FERTILIZER (0002,6-10)	91.00 LB/TON
FRIT MANUFACTURING (0002,8-13)	16.00 LB/TON
CALCIUM CARBIDE (0002,8-5)	66.00 LB/TON

TOTAL PROCESS EMISSION IS THE SUM OF EACH SOURCE WEIGHTED BY THE PERCENTAGE OF PRODUCTION OF EACH SOURCE SEE FOOTNOTE 6101

6113

NOX EMISSION FROM PROCESSES IS AS FOLLOWS-

NITRIC ACID (0002,5-10)	6.67 LB/TON (80% CONTROLED)
SULFURIC ACID (6107,13)	0.17 LB/TON

FTN. 6114-6120

NITRATE FERTILIZER (0002,6-9) 3.90 LB/TON
TOTAL PROCESS EMISSION IS THE SUM FROM EACH SOURCE WEIGHTED BY PERCENTAGE OF PRODUCTION OF EACH SOURCE (FOOTNOTE 6101). TOTAL EMISSION IS THE SUM OF PROCESS EMISSION AND EMISSION FROM STEAM GENERATION (SEE FOOTNOTE 6111)

6114

MAJOR PROCESS EMISSIONS OF SOX ARE AS FOLLOWS

SULFURIC ACID	(6107,7)	40.00 LB/TON
PHOSPHORIC ACID	(6105,29)	0.13 LB/TON
CALCIUM CARBIDE	(0002,8-5)	6.00 LB/TON

TOTAL PROCESS EMISSION IS THE SUM OF THE ABOVE SOURCES WEIGHTED BY THEIR RESPECTIVE PERCENTAGE OF PRODUCTION (FOOTNOTE 6106). TOTAL EMISSION IS THE SUM OF THE PROCESS EMISSION AND THE EMISSION FROM STEAM GENERATION (SEE FOOTNOTE 6111)

6115

HYDROCARBON EMISSION FROM PROCESSES IS REPORTED FOR AMMONIA PRODUCTION, 90.00 LB/TON (0002,5-3), AND FOR CALCIUM CARBIDE MANUFACTURING, 18.0 LB/TON (0002,8-5). TOTAL PROCESS EMISSION IS THE SUM OF THE ABOVE WEIGHTED BY THEIR RESPECTIVE PERCENTAGE OF PRODUCTION (FOOTENOTE 6101). TOTAL EMISSION IS THE SUM OF THE PROCESS EMISSION AND EMISSION FROM STEAM GENERATION (SEE FOOTNOTE 6111)

6116

CO EMISSION FROM PROCESSES IS REPORTED FOR NITRIC ACID, 16.6 LB/TON (6108,10), AND AMMONIA PRODUCTION, 100.0 LB/TON (ASSUMING 50PC CONTROL) (0002,5-3). TOTAL PROCESS EMISSION IS THE SUM OF THE ABOVE WEIGHTED BY THE PERCENTAGE OF PRODUCTION OF EACH SOURCE.(FOOTNOTE 6101). TOTAL EMISSION IS THE SUM OF THE PROCESS AND THE STEAM GENERATION EMISSION.

6117

OTHER SOURCES OF EMISSION INCLUDE A VARIETY OF COMPOUNDS AND CHEMICALS. THE REPORTED PROCESSES ARE AS FOLLOWS-

AMMONIA (0002,5-3)	10.000 LB AMMONIA/TON
CHLOR-ALKALI (0002,5-6)	80.000 LB CHLORINE/TON
HYDROFLUORIC ACID (0002,5-9)	0.200 LB FLUORIDE/TON
NITRIC ACID (6108,10)	0.077 LB HCN/TON
PHOSPHORIC ACID (6105,19)	1.100 LB FLUORIDE/TON
SODA ASH (0002,5-17)	7.000 LB AMMONIA/TON
NITRATE FERTILIZER (0002,6-9)	1.900 LB AMMONIA/TON
PHOSPHATE FERTILIZER (0002,6-10)	0.320 LB FLUORIDE/TON
FRIT (0002,8-13)	5.000 LB FLUORIDE/TON
HYDROCHLORIC ACID (0002,5-9)	0.200 LB HCL/TON

TOTAL PROCESS EMISSION IS THE SUM OF THE ABOVE WEIGHTED BY EACH SOURCES PERCENTAGE OF PRODUCTION (FOOTNOTE 6101). TOTAL EMISSION IS THE SUM OF PROCESS EMISSION AND ALDEHYDE AND ORGANIC EMISSION FROM FUELS USED IN STEAM GENERATION. (FOOTNOTE 6111)

6118

THE ONLY SOLID WASTE REPORTED IS FOR THE PRODUCTION OF CHLORINE, 23.15 LB/TON (6111,A). CHLORINE MAKES UP APPROXIMATELY 8.2 PC OF THE TOTAL INORGANIC CHEMICAL PRODUCTION (FOOTNOTE 6101).

6119

ENERGY EFFICIENCY IS CALCULATED BY DIVIDING ENERGY OF FUEL TYPE USED IN 1967 (0041,SR4-18/SR4-19) BY PRODUCTION IN 1967, 92.1 MILLION TON (6100) AND (0025,255). CONVERSION FACTORS FOR FUEL ARE FOUND IN (0005,38). INCLUDED IN FUEL EFFICIENCY IS 2.42+05 BTU COAL, 1.70+04 BTU COKE, 4.23+06 BTU NATURAL GAS AND 7.21+05 BTU FUEL OIL (ASSUMED TO BE RESIDUAL) (0039,30) AND SEE FOOTNOTE 6110

6120

ESSENTIALLY ALL THE FUEL INPUT FOR HEAT AND POWER INTO THE ORGANIC 29

FTN. 6121-6125

CHEMICAL INDUSTRY IS USED TO PRODUCE STEAM OR FOR DIRECT FIRE, (6114) AND (0007,119). EITHER USE IS DIRECT COMBUSTION OF FUEL , THEREFORE THE EMISSION FACTORS ARE ASSUMED THE SAME, (0002, 1-3/1-9). THE FUEL INPUT FOR HEAT AND POWER IS AS FOLLOWS, (0041,SR4-18/SR4-19) 1.55+06 TON COAL, 6.36+06 BARREL DISTILLATE, 8.45+06 BARREL RESIDUAL AND 7.56+05 MMCF NATURAL GAS. THE EMISSION FROM FUELS USED FOR ONE TON OF PRODUCT (ALSO SEE FOOTNOTE 6119) IN TONS IS AS FOLLOWS-

	PART	SOX	CO	HYDCARB	NOX	ALDHY	ORG
COAL	1.57-03	1.06-03	1.68-05	8.41-06	1.26-04	4.20-08	-
DIST	5.18-07	1.11-06	6.90-09	1.04-07	2.07-06	6.90-08	-
RESID	1.05-06	7.29-06	9.17-09	1.38-07	2.75-06	4.59-08	-
NA GAS	7.38-05	2.46-06	1.64-06	1.64-04	5.13-04	1.23-05	2.87-05
TOTAL	1.65-03	1.07-03	1.85-05	1.73-04	6.44-04	1.25-05	2.87-05

PARTICULATE EMISSION FROM PROCESSES ARE GIVEN BELOW, LB/TON-

CARBON BLACK (0002,5-4)	60.0	(96.1PC PRODUCTION (0025,255)
	2300.0	(3.9PC PRODUCTION (0025,255)
EXPLOSIVES (0002,5-8)	36.4	
PLASTICS (0002,5-14)	10.5	
PRINTING INK (0002,5-15)	2.0	
DETERGENT (0002,5-16)	14.0	(CYCLONE, 85.0PC CONTROL)
PAINT (0002,5-11)	2.0	(PER TON PIGMENT)

TOTAL PROCESS EMISSION IS THE SUM OF EACH SOURCE WEIGHTED BY THE SOURCES PERCENTAGE OF PRODUCTION, SEE FOOTNOTE 6100. TOTAL PARTICULATE EMISSION IS THE SUM OF THE PROCESS AND FUEL USE EMISSION.

6122

NOX EMISSION FROM PROCESSES ARE AS FOLLOWS, IN LB/TON-

ADIPIC ACID	12.0	
EXPLOSIVES	17.0	(WITH BUBBLE CAP ABSORPTION)
TEREPHTHALIC ACID	13.0	

TOTAL PROCESS EMISSION IS THE SUM OF EACH SOURCE WEIGHTED BY THE PC OF PRODUCTION OF EACH SOURCE (FOOTNOTE 6100). TOTAL NOX EMISSION IS THE SUM OF PROCESS AND FUEL USE (FOOTNOTE 6120) EMISSION.

6123

PROCESS EMISSION OF SOX IS REPORTED FOR EXPLOSIVES ONLY, 96.0 LB/TON (0002,5-8). EXPLOSIVES MAKE UP APPROXIMATELY .90 P OF TOTAL PRODUCTION. TOTAL PROCESS EMISSION = 4.80-02 TON TOTAL SOX EMISSION IS THE SUM OF THE PROCESS AND FUEL USE (FOOTNOTE 6120) EMISSION.

6124

HYDROCARBON EMISSION FROM PROCESSES IS AS FOLLOWS, LB/TON-

CARBON BLACK (0002,5-4)	11500.0	(3.9PC OF PRODUCTION)
	1800.0	(12.5PC PRODUCTION, GAS)
	400.0	(83.6PC PRODUCTION, OIL)
PAINT & VARNISH (0002,5-11)	4.0	(AFTERBURNERS)
SYNTHETIC FIBERS (0002,5-20)	7.0	(NYLON)
SYNTHETIC RUBBER (0002,5-21)	83.0	

TOTAL PROCESS EMISSION IS THE SUM FROM EACH SOURCE WEIGHTED BY THE PERCENTAGE OF PRODUCTION OF EACH SOURCE (FOOTNOTE 6100). TOTAL HYDROCARBON EMISSION IS THE SUM OF THE PROCESS AND FUEL USE EMISSION (FOOTNOTE 6120)

6125

CO EMISSION FROM PROCESSES IS REPORTED FOR CARBON BLACK ONLY- 3.35+04 LB/TON CHANNEL PROCESS (3.9PC PRODUCTION (0025,263)) 5.30+03LB/TON GAS FURNACE (12.5PC PRODUCTION (0025,263)) AND 4.50+03LB/TON OIL FURNACE (83.6PC PRODUCTION (0025,263)). TOTAL CO EMISSION IS THE SUM OF THE CARBON BLACK EMISSION AND EMISSION FROM FUEL USE (FOOTNOTE 6120).CARBON BLACK REPRESENTS 1.24 PC OF TOTAL PRODUCTION (SEE FOOTNOTE 6100)

FTN. 6126-6132

6126

OTHER EMISSIONS CONSIST PRIMARILY OF ORGANICS WITH AMOUNTS OF OTHER COMPOUNDS, LB/TON-

CARBON BLACK (0002,5-4)	8.51	(H2S)
PHTHALIC ANHYDRIDE (0002,5-13)	11.00	(ORGANIC)
PLASTICS (0002,5-14)	17.70	(GASES)
PRINTING INK (0002,15)	235.00	(ORGANIC,50PC SETTLING)
SYNTHETIC FIBERS (0002,5-20)	83.00	(CS2,H2S,OIL VAPOR)

TOTAL PROCESS EMISSION IS THE SUM FROM EACH SOURCE WEIGHTED BY THEIR RESPECTIVE PERCENTAGES OF PRODUCTION (FOOTNOTE 6100). TOTAL EMISSION IS THE SUM OF THE PROCESS EMISSION AND THE FUEL USE EMISSION (FOOTNOTE 6120)

6127

ACID EFFLUENT IS REPORTED FOR ACETIC ACID AND ANHYDRIDE (6115, C126) AS .02 TON PER TON OF PRODUCT. ACETIC ACID AND ANHYDRIDE MAKES UP APPROXIMATELY 1.45PC OF TOTAL PRODUCTION, FOOTNOTE 6100.

6128

PO4 EFFLUENT IS REPORTED FOR POLYSTYRENE (6115,C161) AS 5.08-03 TON PER TON PRODUCT. POLYSTYRENE PRODUCTION AMOUNTS TO 2.0PC OF TOTAL PRODUCTION (FOOTNOTE 6100)

6129

AN ESTIMATE OF SUSPENDED SOLIDS CAN BE OBTAINED FROM (0016,E98, E101,E105) USING THE PROCEEDURE DEVELOPED IN FOOTNOTE 6108. SUSPENDED SOLIDS AND WASTEWATER FLOW FOR THE PLANTS REPORTING ARE AS FOLLOWS-

	UNTREATED			TREATED		
	COMP	MGD	SS	COMP	MGD	SS
COAL TAR PRODUCTS	-	-	-	3	71.10	3675.0
ORGANIC CHEMICALS	16	91.1	403673.0	13	884.00	60179.0
PLASTICS/RESINS	7	45.6	15320.0	6	8.22	3572.0
SYNTHETIC RUBBER	3	58.8	60760.0	3	114.00	21400.0
CELLULOSIC MAN-MADE FIBERS	4	30.1	42740.0	6	19.56	6066.0
ORGANIC FIBERS, NONCELLU.	2	0.7	175.0	4	23.80	22244.0
PHARMACEUTICALS	-	-	-	1	1.00	8220.0
DETERGENTS	5	10.3	8115.0	1	1.70	5519.0
GUM AND WOOD CHEMICALS	1	0.0	425.0	-	-	-
AGRICULTURAL PESTICIDES	1	0.3	876.0	2	0.40	62.0
EXPLOSIVES	4	75.0	20605.0	2	2.06	14004.0
CARBON BLACK	1	0.6	1000.0	3	0.15	143.0

AVERAGE SS/MGD WEGHTED BY NUMBER OF PLANTS = 1795.12 LB/MGD FROM (6104,IW/34) WASTEWATER AMOUNTS TO 13.3 GPD/TON PRODUCT. TOTAL SS = 1795.12 LB/MGD X -06 MGD/GAL X 13.3 GPD/TON = 2.39-02 LB/TON OR 1.94-05 TON SS

6130

USING THE PROCEDURE OF FOOTNOTE 6129, BOD CAN BE ESTIMATED FROM (0016,E98,E99,E103). AVERAGE BOD/MGD WEIGHTED BY NUMBER OF PLANTS = 2950.24 LB/MGD. FROM (6104, IW/34) WASTEWATER AMOUNTS TO 13.3 GPD/TON PRODUCT. TOTAL BOD = 2950.24 LB/MGD X -06 MGD/ 6 X 13.3 GPD/TON = 3.92-02 LB/TON OR 1.96-05 TON

6131

COD CAN BE ESTIMATED FROM (0016,E98,E100,E104) USING THE TECHNIQUE OF FOOTNOTE 6129. AVERAGE COD/MGD WEIGHTED BY NUMBER OF PLANTS = 7667.52 LB/MGD. FROM (6104,IW34) WASTEWATER AMOUNTS TO 13.3 GPD/TON PRODUCT. TOTAL COD = 7667.52 LB/MGD X -06 MGD/GAL X 13.3 GPD/TON = 1.02-01 LB/TON OR 5.10-05 TON

6132

ORGANIC EFFLUENT IS REPORTED FOR THE FOLLOWING:

ACETIC ACID AND ANHYDRIDE (6115,C126)	2.00-02 TON/TON
ACETONE (6115,C127)	8.00-02 TON/TON
ACRYLATES (6115,C131)	6.50-03 TON/TON
PHENOL (6115,C157)	1.40-04 TON/TON

FTN. 6133-6303

BUTADIENE (6115,C137)	4.00-06 TON/TON	799
BUTANOL (6115,C138)	1.00-01 TON/TON	899
ETHYL BENZENE AND STYRENE (6115,C147)	5.00-02 TON/TON	999
LD POLYETHYLENE (6115,C160)	6.00-06 TON/TON	1099
UREA (6115,C166)	4.00-04 TON/TON	1199
POLYSTYRENE (6115,C161)	3.43-03 TON/TON	1299
PHENOLIC RESINS (6116,77)	4.30-02 TON/TON	1399
UREA & MELAMINE RESINS (6116,68)	1.10-01 TON/TON	1499

TOTAL ORGANICS IS THE SUM OF THE ABOVE SOURCES 1599
WEIGHTED BY THE PERCENTAGE OF PRODUCTION OF EACH SOURCE, SEE 1699
FOOTNOTE 6100. 1799

6133 199

SOLID WASTE IS REPORTED FOR THERMOPLASTICS (6117). AVERAGE SOLID 299
WASTE GENERATED IS 1.1PC OF PRODUCTION OF THERMOPLASTICS FOR 399
1969 (6117,32). ASSUMING NO MAJOR CHANGE IN PROCESSES, TOTAL 499
SOLID WASTE FROM THERMOPLASTICS IS 22.00 LB/TON PRODUCT. 599
THERMOPLASTICS MAKE UP APPROXIMATELY 6.60PC OF TOTAL ORGANIC 699
CHEMICAL PRODUCTION (FOOTNOTE 6100) 799

6134 199

EQUAL TO THE SUM OF THE LISTED QUANTITIES 299

6300 199

INCLUDED UNDER THIS CLASSIFICATION ARE FLAT GLASS, FIBROUS GLASS, 299
GLASS CONTAINERS AND SCIENTIFIC, TECHNICAL AND INDUSTRIAL 399
GLASSWARE. SOURCES OF DATA AND CONVERSIONS USED IF NEEDED ARE 499
AS FOLLOWS- FLAT GLASS (6305), 158.22 LB/FT3 (6309,43) 599
FIBROUS GLASS (6307) 699
GLASS CONTAINERS (6306), 0.53 LB/UNIT 799
(6311,MC67(2)-32A) 899
SCIENTIFIC, TECHNICAL AND INDUSTRIAL GLASSWARE 999
(6308), 0.80 LB/UNIT (6311,MC67(2)-32A) 1099

6301 199

THE ENERGY CONSUMED- SHEET GLASS = 7.51 KWH/LB (6311,MC(67(2)-32A) 299
PLATE GLASS = 3.25 KWH/LB (6312,14), GLASS CONTAINERS = 4.00 399
KWH/LB (6312,15), MISCELLANIOUS GLASS = 4.0 KWH/LB (6312,15) 499
THE ENERGY BREAKDOWN BY PERCENTAGE OF FUEL TYPE USED IS AS 599
FOLLOWS, +06 BTU/TON- 699

	COAL	RESID	DIST	NAT GAS	ELEC	
SHEET GLASS		3.56		36.29	11.44	799
PLATE AND FLOAT		1.54		15.70	4.95	899
CONTAINER GLASS	1.89	1.42	0.30	19.04	4.65	999
MISCELLANIOUS	0.41	0.94	0.30	19.74	5.91	1099

INCLUDED FOR SHEET AND PLATE GLASS IS 3.56+06 BTU/TON AND 1199
1.54+06 BTU/TON RESPECTIVELY UNDIFFERETIATED FUEL, WHICH IS 1299
ASSUMED TO BE RESIDUAL. THE WEIGHTED AVERAGE BTU/TON PRODUCT 1399
FOR EACH FUEL TYPE IS, COAL = 1.55+06 BTU, RESIDUAL = 1.63+06 1499
BTU, DISTILLATE = 2.97+05 BTU, NATURAL GAS = 2.23+07 BTU, 1599
ELEC = 5.93+06 BTU (WEIGHTING IS BY PC OF TOTAL PRODUCTION- 1699
SHEET = .06, PLATE = .04, CONTAINER = .70 MISCELANIOUS = .20) 1799

6302 199

INCLUDED UNDER THIS CLASSIFICATION ARE CLAY CONSTRUCTION PRODUCTS, 299
CLAY REFRACTORIES AND POTTERY AND RELATED PRODUCTS. SOURCES OF 399
DATA AND CONVERSIONS AS NEEDED ARE AS FOLLOWS- 499
CLAY CONSTRUCTION PRODUCTS (6303), 6.50 LB/BRICK (0002,A7) 599
TILE 130.00 LB/FT3 (6405, 699
433) 799
CLAY REFRACTORIES (6304), 2.25 - 8.50 LB/9INCH BRICK (0023, 899
6-209) 999
POTTERY AND RELATED, 500 DOLLARS PER TON (6300,64) 1099

6303 199

FTN. 6304-6311

FUEL EFFICIENCY IS CACULATED BY DIVIDING AMOUNT OF FUEL AND ELECTRICITY USED BY TONNAGE OF PRODUCTION (6311,MC67(2)-32B/ MC67(2)-32C) IN 1967.

6304

WITH CYCLONE SCRUBBER, PARTICULATE EMISSION FOR BRICK AND RELATED PRODUCTS IS 18.00 LB/TON IN THE DRYING PROCESS AND 19.00 LB/ TON IN THE GRINDING PROCESS, (0002,8-4,8-8). FOR CURING AND FIRING USING COAL FIRING, PARTICULATE EMISSION IS REPORTED AS 7.5A LB/TON COAL (A=14.4 (6302,16)), (0002;8-4). SINCE THE PROCESSES ARE ESSENTIALLY THE SAME FOR POTTERY AND RELATED PRODUCTS,THE EMISSIONS CAN BE CONSIDERED THE SAME. TOTAL PARTICULATE EMISSION, WITH 11PCOF PRODUCTION FROM COAL FIRED FURNACES USING .03 TON OF COAL PER TON OF PRODUCT (SEE FOOTNOTE 6303) = 18.00 LB/TON + 19.00 LB/TON + (7.5 X 14.4 X.03) LB/TON X.11 = 37.36 LB/TON OR 1.86-03 TON/TON PRODUCT.

6305

NOX EMISSION IS DEPENDENT UPON TYPE OF FUEL USED FOR CURING AND FIRING (0002,8-4)- GAS FIRED 0.60 LB NOX/TON PRODUCT
OIL FIRED 1.30 LB NOX/TON PRODUCT
COAL FIRED 1.50 LB NOX/TON PRODUCT
ALLOCATING EMISSION BY PERCENTAGE OF FUEL TYPE USED (SEE FOOTNOTE 6303), TOTAL NOX EMISSION = 0.60 LB/TON X 0.85 + 1.30 LB/TON X .04 + 1.50 X 0.11 = 0.727 LB/TON OR 3.00+04 TON PER TON BRICK

6306

FLUORIDE EMISSION HAS BEEN ESTIMATED AT 0.80 LB/TON (0002,8-4) OR 4.00-04 TON PER TON BRICK.

6307

ABOVE A FIRING TEMPERATURE OF 2500F, SOX MAY EXIST DEPENDING UPON SULFUR CONTENT OF MATERIAL BEING FIRED (0002,8-3). SINCE MOST KILNS USED FOR MANUFACTURE OF CLAY PRODUCTS ARE FIRED LESS THAN 2500F (6300,69/73) SOX CAN BE CONSIDERED NEGLIGABLE.

6308

PARTICULATE EMISSION FROM GLASS MANUFACTURING IS STATED AS 2.00 LB /TON (0002,8-13). PATICULATE EMISSION FROM FIBER GLASS MANUFACTURING = 58.50 LB/TON OR 0.029 TON/TON. TOTAL EMISSION EQUALS THE AVERAGE EMISSION FROM THESE TWO SOURCES WEIGHTED BY THEIR RESPECTIVE PC OF PRODUCTION (SEE FOOTNOTE 6300). TOTAL EMISSION = 0.001 TON X 0.930 + 0.029 X 0.07 = 0.00113 TON. (GLASS MANUFACTURING INCLUDES FLAT, CONTAINER AND SCIENTIFIC)

6309

CLASSIFIED UNDER CEMENT AND RELATED ARE SIC 3241,HYDRAULIC CEMENT AND SIC 327 CONCRETE, GYPSUM, AND PLASTER PRODUCTS. SOURCES OF DATA AND CONVERSIONS WHERE NECESSARY ARE AS FOLLOWS- CEMENT (0011,660), GYPSUM PRODUCTS (0025,561), LIME (0011,661) , CONCRETE BLOCK AND BRICK (6314,81), CONCRETE PRODUCTS, NEC- AVERAGE VALUE OF $45.00 PER TON (6310,MC67(2)-32C) AND (0009,366)

6310

FUEL EFFICIENCY OBTAINED FROM (0025,287) FOR CEMENT AND BY FUELS AND ELECTRICITY USED DIVIDED BY PRODUCTION (6310,MC67(2)-32C) FOR THE OTHER PRODUCTS. CONVERSIONS FOR FUELS (0005,38).

6311

PARTICULATE EMISSION FOR CEMENT AND RELATED IS AS FOLLOWS:

PORTLAND CEMENT 12.80 LB/BBL OR 0.034 TON/TON DRY PROCESS AND 8.80 LB/BBL OR 0.023 TON/TON WET PROCESS (0002,8-7). 80PC CONTROL

CONCRETE BATCHING 0.11 LB/YD3 OR C.055 TON/TON (0002,8-11), 50PCOF PLANTS CONTROLED. DIRECT ENERGY USE FOR PROCESS IS SMALL.

CONCRETE PRODUCTS EMISSION INCLUDES CONCRETE BATCHING, 0.055

TON AND FROM CURING STEAM GENERATION, 1099
3.00+06 TON (0002,8-11) AND (SEE FOOTNOTE 1199
6310) 1299
GYPSUM PRODUCTS EMISSION FOR CALCINING GYPSUM, WITH FABRIC 1399
FILTER CONTROL IS 0.302 LB/TON OR 0.0002 TON 1499
/TON (0002,8-14) 1599
LIME MANUFACTURE EMISSION, WITH CYCLONE AND 50PCOF PRODUCTION 1699
FROM EACH KILN TYPE IS 41.10 LB/TON OR 0.0211 1799
TON (0002,8-15) 1899
TOTAL EMISSION IS WEIGHTED BYPC OF TOTAL PRODUCTION OF EACH 1999
SOURCE. (PORTLAND CEMENT = 0.14, READY MIXED CONCRETE = 0.69, 2099
CONCRETE BLOCK & BRICKS = 0.06, CONCRETE PRODUCTS = 0.06, 2199
GYPSUM PRODUCTS = 0.02, LIME = 0.03 OF TOTAL PRODUCTION) 2299

6312 199

NOX EMISSION FOR CEMENT AND RELATED IS DEPENDENT UPON THE TYPE OF 299
FUEL USED. AVERAGE EMISSION FOR CEMENT IS 273 PPM/TON FEED 399
(6301,16) AT 70000 SCF/TON FEED (6301,10) AND 600 LB/BBL FEED. 499
(6301,06). BY CONVERSION,NOX EMISSION = 7.00-05 TON NOX/TON 599
CEMENT. EMISSION FOR CONCRETE PRODUCTS IS FROM CURING STEAM 699
GENERATION.(SEE FOOTNOTE 6311)- NOX = 1.10-05 TON. EMISSION 799
FROM GYPSUM PRODUCTS OCCURS FROM BURNING OF FUELS FOR EXTERNAL 899
FIRING. NOX EMISSION FOR GYPSUM PRODUCTS WEIGHTED BY PC OF 999
FUEL USED:= 1.98-04 TON.(0002,1-3/1-9). DATA FOR NOX EMISSION 1099
FROM LIME MANUFACTURING IS UNAVALABLE. EMISSION FROM READY 1199
MIXED CONCRETE IS NEGLIGIBLE. TOTAL NOX EMISSION IS THE SUM OF 1299
THE INDIVIDUAL SOURCES WEIGHTED BY PERCENTAGE THAT EACH 1399
PRODUCT CONTRIBUTES TO TOTAL PRODUCTION (SEE FOOTNOTE 6311) 1499

6313 199

REACTION WITH FEED MATERIAL (CARBONATE), WILL REDUCE POTENTIAL SOX 299
EMISSION FROM A CEMENT KILN BY AN AVERAGE OF 59PC (6302,15) 399
BASED UPON THIS AND AVERAGE SULFUR CONTENT OF FUEL USED, 499
COAL =3.32 PC PER TON (6302,16), DIST =0.224 PC/GAL (6317,7), 599
RESID =1.0 PC/GAL (6318,164), NA GAS =0.286 LB/MMCF (0002,1-9) 699
, SOX EMISSION FOR CEMENT = 1.90-03 TON. THE MANUFACTURE OF 799
LIME IS SIMILAR TO CEMENT IN FIRING AND CARBONATE FEED. THE 899
EMISSION CAN BE CONSIDERED SIMILAR AND DEPENDENT UPON FUEL 999
USED. SOX EMISSION FROM LIME = 1.17-03 TON. SOX EMISSION FROM 1099
CONCRETE BLOCK, BRICK AND PRODUCTS OCCURS FROM STEAM 1199
GENERATION (SEE FOOTNOTE 6312), SOX = 1.57-06. SOX EMISSION 1299
FROM GYPSUM PRODUCTS OCCURS FROM FUEL USED FOR INDIRECT FIRING 1399
(SEE FOOTNOTE 6312), SOX = 5.49-04 TON. TOTAL EMISSION IS 1499
THE SUM OF THESE SOURCES WEIGHTED BY THEIR PERCENTAGE OF TOTAL 1599
PRODUCTION (SEE FOOTNOTE 6311) 1699

6314 199

SOURCES OF HYDROCARBONS ARE STEAM GENERATION FOR CONCRETE BLOCK, 299
BRICKS AND PRODUCTS AND FROM INDIRECT FIRING OF GYPSUM 399
PRODUCTS. HYDROCARBON EMISSION WEIGHTED BY PERCENTAGE OF FUEL 499
USED IS AS FOLLOWS (0002,1-3/1-9)- CONCRETE BLOCK, BRICKS AND 599
PRODUCTS = 3.38-06 TON, GYPSUM PRODUCTS = 4.62-04 TON. 699
TOTAL EMISSION IS THE SUM OF THESE EMISSIONS WEIGHTED BY 799
PRODUCTION. THESE SOURCES MAKE UP 14.0 PC OF TOTAL PRODUCTION 899
SEE FOOTNOTE 6311. 999

6315 199

SOURCES OF CO EMISSION ARE THE SAME AS HYDROCARBON EMISSIONS (SEE 299
FOOTNOTE 6314) 399

6316 199

SOURCES OF ALDEHYDES AND OTHER EMISSIONS ARE THE SAME AS HYDRO- 299
CARBON EMISSIONS. (SEE FOOTNOTE 6314) 399

6317 199

INCLUDED UNDER STONE AND RELATED ARE SIC 3281, CUT STONE AND STONE 299
PRODUCTS AND SIC 329 MISCELLANIOUS NONMETALLIC MINERAL 399

FTN. 6318-6324

PRODUCTS. SOURCES OF DATA AND CONVERSIONS WHERE NECESSARY ARE AS FOLLOWS- CUT STONE AND STONE PRODUCTS $61.00 PER TON (0025,1048) AND (6319,21)

ABRASIVE PRODUCTS $895.00 PER TON (0025,154) AND (6319,21)

ASBESTOS PRODUCTS $800.00 PER TON (0025,200) AND (6319,21)

GASKETS AND INSULATIONS AND NONMETALLIC MINERAL PRODUCTS, NEC $200.00 PER TON (6311,MC67(2)-32E) AND (0011,345)

MINERALS, GROUND OR TREATED 1.30+08 TON (6311, MC67(2)-32E) AND (0025)

MINERAL WOOL $80.00 PER TON (6304) AND (0011,345)

NONCLAY REFRACTORIES (6304) AND (0008,6-208)

6318

FUEL EFFICIENCIES ARE OBTAINED BY DIVIDING FUEL USED BY TOTAL PRODUCTION FOR 1967, (6311,MC67(2)-32D/32E)

6319

PARTICULATE EMISSIONS ARE REPORTED FOR NONCLAY REFRACTORIES (0002,8-5), CLAY MANUFACTURING (0002,8-8), MINERAL WOOL MANUFACTURING (0002,8-16), PERLITE MANUFACTURING (0002,8-17), PHOSPHATE ROCK PROCESSING (0002,8-18) AND ROCK PROCESSING (0002,8-19).OTHER SOURCES OF EMISSIONS ARE FROM STEAM GENERATION IN ASBESTOS PRODUCTS (6316,100/118) AND MINERAL WOOL MANUFACTURING (0002,8-15), (0002,1-3/1-9). THE EMISSION FROM EACH OF THE ABOVE SOURCES IS AS FOLLOWS- NONCLAY REFRACTORIES (CONTROLLED CASE) = 63.40 LB/TON, CLAY MANUFACTURING = 37.00 LB/TON, MINERAL WOOL MANUFACTURING = 50.00 LB/TON, PERLITE MANUFACTURING=21.00 LB/TON, PHOSPHATE ROCK PROCESSING=37.00 LB/TON, ROCK PROCESSING = 11.30 LB/TON. FROM STEAM GENERATION THE PARTICULATE EMISSION IS 4.41-04 TON AND 3.12-04 TON RESPECTIVELY. TOTAL EMISSION IS THE SUM OF THE INDIVIDUAL SOURCES WEIGHTED BY THEIR PERCENTAGE OF TOTAL PRODUCTION (CUT STONE = 2.6 PC, ABRASIVES = 0.6PC, ASBESTOS = 0.5 PC, GASKETS AND INSULATION = 1.2PC, MINERALS GROUND = 88.4PC, MINERAL WOOL = 4.5PC, REFRACTORIES = 2.1PC).

6320

NOX EMISSION FROM STEAM GENERATION FOR ASBESTOS PRODUCTS AND MINERAL WOOL MANUFACTURING IS 3.31-04 TON AND 3.13-04 TON RESPECTIVELY (0002,1-3/1-9). TOTAL EMISSION IS THE SUM FROM EACH SOURCE WEIGHTED BY PRODUCTION. SEE FOOTNOTE 6319.

6321

SOX EMISSIONS ARE REPORTED FOR MINERAL WOOL MANUFACTURING AS 0.02 LB/TON FROM THE CUPOLA (0002,8-16). EMISSION FROM STEAM GENERATION FOR ASBESTOS PRODUCTS AND MINERAL WOOL MANUFACTURING IS 2.76-04 TON AND 1.85-04 TON RESPECTIVELY (0002,1-3/1-9). TOTAL EMISSION IS THE SUM FROM EACH SOURCE WEIGHTED BY PERCENTAGE OF PRODUCTION. SEE FOOTNOTE 6319.

6322

HYDROCARBON EMISSIONS OCCUR FROM FUEL USED IN STEAM GENERATION FOR MINERAL WOOL AND ASBESTOS PRODUCTS.(0002,1-3/1-9). THE EMISSION FROM EACH SOURCE IS 6.78-05 TON AND 6.97-05 TON RESPECTIVELY. TOTAL EMISSION IS THE SUM WEIGHTED BY PERCENTAGE OF PRODUCTION. SEE FOOTNOTE 6319

6323

CO EMISSIONS OCCUR FROM FUEL USED IN STEAM GENERATION FOR MINERAL WOOL AND ASBESTOS PRODUCTS. THE EMISSION FROM EACH SOURCE IS 3.66-06 TON AND 5.07-06 TON (0002,1-3/1-9). TOTAL EMISSION IS THE SUM OF EACH SOURCE WEIGHTED BY PRODUCTION OF EACH SOURCE. SEE FOOTNOTE 6319.

6324

FTN. 6325-6332

INCLUDED UNDER ALDEHYDES ETC. IS FLUORIDE FROM NONCLAY REFRACTORIES = 1.3 LB/TON (0002,8-6) AND ALDEHYDES AND ORGANICS FROM FUEL USED IN STEAM GENERATION FOR MINERAL WOOL AND ASBESTOS PRODUCTS; 4.26-06 TON ALDEHYDE, 1.16-05 TON ORGANIC AND 5.09-06 TON ALDEHYDE, 1.18-05 TON ORGANIC RESPECTIVELY. TOTAL IS THE SUM FROM EACH SOURCE WEIGHTED BY PERCENTAGE OF PRODUCTION. SEE FOOTNOTE 6319

6325

AN AVERAGE NOX EMISSION FOR GLASS MANUFACTURING OF 0.40 TON PER DAY IS REPORTED (0008,B-1/B-4). ASSUMING AN AVERAGE PRODUCTION RATE OF 500 TON PER DAY, NOX EMISSION = 8.00-04 TON/TON PRODUCT

6326

SOX EMISSION FROM A GLASS FURNACE IS GIVEN AS 65 PPM FOR A EXHAUST GAS FLOW OF 6500 SCFM (6313,639). ASSUMING THIS IS THE STACK EXIT FLOW, OPERATION IS 24 HOURS PER DAY AND 500 TON PER DAY PRODUCTION, TOTAL EMISSION = 4.19-05 TON/TON PRODUCT.

6327

EMISSIONS OF FLUORIDE AND B2O3 ARE REPORTED FOR A GLASS FURNACE AS 60PPM AND 0.025 GRAIN/SCF. USING THE ASSUMPTIONS OF FOOTNOTE 6326 EMISSION IS 3.87-05 TON FLUORIDE AND 3.34-04 TON B2O3

6328

EFFLUENTS FOR SEVERAL FLAT GLASS MANUFACTURING PLANTS ARE GIVEN BY (6316,40/41). AVERAGE EFFLUENT WEIGHTED BY FLOW OF EFFLUENT/TON IS AS FOLLOWS-

(LB/TON)	SS	TS	BOD	PHOS	HEXANE
	2.72	48.87	2.39	0.64	2.50

FLAT GLASS MAKES UP APPROXIMATELY 11 PC OF TOTAL PRODUCTION.

6329

TOTAL DISSOLVED SOLIDS IS OBTAINED BY SUBTRACTING SS FROM TS (SEE FOOTNOTE 6328)

6330

DATA ON EFFLUENT LEVELS FOR THE CEMENT AND RELATED CLASSIFICATION ARE GIVEN FOR HYDRAULIC CEMENT, CONCRETE PRODUCTS, READY MIXED CONCRETE, GYPSUM PRODUCTS AND LIME MANUFACTURE (6316,47/100). EFFLUENT VALUES FOR PROCESS WATER AND COOLING WATER IS INCLUDED IF ENERGY IS CONSUMED. EFFLUENT FOR WASH AND RINSE WATER IS EXCLUDED. AVERAGE LEVELS WEIGHTED BY FLOW FOR EACH EFFLUENT SOURCE IS AS FOLLOWS- TON/TON PRODUCT

NO EFFLUENT CAN BE FOUND FROM AN ENERGY USE FOR READY MIXED CONCRETE

	CEMENT	CONCRETE PRODUCTS	GYPSUM	LIME
SS	1.77-04	1.00-05	3.00-06	8.85-05
TS		8.00-04		1.95-04
SO4	1.14-04			
CL	3.36-05			
K	5.37-05			
CA	5.67-05			
NA	3.33-05			
BOD		5.00-06	3.50-06	
COD			5.10-06	
CAOH				4.50-04
CACO3				4.50-04

TOTAL EFFLUENT OF EACH TYPE IS THE SUM OF EACH SOURCE WEIGHTED BY PERCENTAGE OF TOTAL PRODUCTION: SS = 2.81-05, TS = 9.87-05, SO4 = 1.53-05, CL = 4.51-06, K = 7.21-06, CA = 7.61-06, NA = 4.47-06, BOD = 6.50-07, COD = 1.20-07, CAOH = 1.57-05, CACO3 = 1.57-05. SEE FOOTNOTE 6311.

6331

TOTAL DISSOLVED SOLIDS IS EQUAL TO TS MINUS SS. (SEE FOOTNOTE 6330)

6332

EFFLUENT FOR THE STONE AND RELATED INDUSTRY IS GIVEN FOR ASBESTOS

FTN. 6333-6404

PRODUCTS ONLY. NO DATA WAS AVAILABLE FOR THE OTHER PRODUCTS IN THIS GROUP. THE AVERAGE EFFLUENT WEIGHTED BY FLOW IS AS FOLLOWS- SS = 3.41-04 TON, TS = 5.13-02 TON, BOD = 3.62-04 TON, COD = 1.85-04 TON. ASBESTOS PRODUCTION MAKES UP 0.5 PC OF TOTAL PRODUCTION. SEE FOOTNOTE 6319

6333

TOTAL DISSOVED SOLID = TS - SS (SEE FOOTNOTE 6332)

6400

INCLUDED UNDER MEAT AND DAIRY PRODUCTS ARE THE SIC CODES 201 AND 202. SOURCES OF INFORMATION ON PRODUCTION ARE (6400) AND (0011,581/622).

6401

ENERGY PER MEASURE IS COMPUTED BY DIVIDING FUEL TYPES USED IN 1967 (0041) BY PRODUCTION IN 1967 (6402). CONVERSION FACTORS FOR FUEL QUANTITY TO BTU (0005,38).

6402

AIR EMISSIONS FROM MEAT AND DAIRY PRODUCTS OCCUR PRIMARILY FROM USE OF FUEL FOR STEAM GENERATION AND HEATING. ASSUMING THAT ESSENTIALLY ALL FUELS INPUT ARE USED FOR STEAM GENERATION AND HEATING, THE AMOUNTS OF EACH FUEL TYPE USED PER TON OF PRODUCT ARE AS FOLLOW (SEE FOOTNOTE 6401)- COAL = 1.21-02 TON, DISTILLATE = 2.56-02 GALLON, RESIDUAL = 2.51-02 GALLON, NATURAL GAS = 1.04-03 MMCF. USING THE ABOVE AND THE EMISSION FACTORS FROM (0002,1-3/1-9), THE TOTAL AIR EMISSIONS ARE AS FOLLOWS IN TONS-

PART	SOX	CO	HYDCARB	NOX	ALDEHYD	ORGANIC
1.14-03	7.66-04	1.23-05	2.71-05	1.58-04	1.64-06	3.66-06

6403

WATER EFFLUENT FOR MEAT AND DAIRY PRODUCTS ARE AS FOLLOWS TON/TON

MEAT PACKING	0.01530	TON COD (6403,32)
	0.00740	TON BOD (6407,40,58)
POULTRY PROCESSING	0.00840	TON BOD (6404) AND (6405,IW4)
	0.01080	TON COD (6404)
	0.00483	TON DS (6404)
	0.00563	TON SS (6404) AND (6405,IW4)
	0.00225	TON GREASE (6404) AND (6405,IW4)
CREAMERY BUTTER	0.11900	TON BOD (6408,9-17,9-35)
CHEESE	0.10500	TON BOD (6408,9-46,9-64)
	0.00064	TON PO4 (6406)
	0.00007	TON NO3 (6406)
	0.00760	TON SS (6406)
CONDENS & EVAP MILK	0.00391	TON BOD (6408,9-79,9-96)
ICE CREAM & FROZEN	0.00088	TON BOD (6408,9-111,9-126)
FLUID MILK	0.00010	TON BOD (6408,9-141,9-148)

TOTAL EFFLUENT OF EACH TYPE IS THE SUM FROM EACH SOURCE WEIGHTED BY THE PC OF TOTAL PRODUCTION OF EACH SOURCE (MEAT PACKING = 0.23, POULTRY PROCESSING = 0.08, CREAMERY BUTTER = 0.006, CHEESE = 0.012, COND & EVAP MILK = 0.014, ICE CREAM & FROZEN = 0.018, FLUID MILK = 0.63)

6404

INCLUDED UNDER BAKERY, SUGAR & CONFECTIONARY AND RELATED PRODUCTS ARE SIC 206 AND SIC 207. DATA FOR PRODUCTION AND CONVERSION, WHERE NECESSARY, IS AS FOLLOWS-

BAKERY PRODUCTS	AVERAGE VALUE (6402), (6409,5) AND (0009,335)
SUGAR PRODUCTS	(6400,111)
CONFECTIONARY & RELATED	AVERAGE VALUE (6402), (6409,6) AND (0009,335)

6405

ENERGY PER MEASURE IS CALCULATED BY DIVIDING ENERGY OF FUEL TYPES USED (0041) BY PRODUCTION (6402) IN 1967. CONVERSION FACTORS FOR FUEL TYPES (0005,38).

6406

ESSENTIALLY NO AIR EMISSION FROM PROCESS USE OF ENERGY COULD BE FOUND. THE ONLY EMISSION OCCURS FROM THE USE OF FUELS FOR STEAM GENERATION AND INDIRECT HEATING. THE EMISSION FROM BOTH SOURCES CAN BE CONSIDERED THE SAME, THUS FROM FOOTNOTE 6405, 3.70-02 TON OF COAL, 1.71-03 TON OF COKE, 8.48-02 BARREL OF DISTILLATE, 5.05-02 BARREL RESIDUAL AND 2.66-03 MMCF NATURAL GAS PER TON OF PRODUCT IS USED. FROM (0002,1-3/1-9) THE EMISSIONS ARE AS FOLLOWS-

PART	SOX	CO	HYDCARB	NOX	ALDEHYD	ORGANIC
3.90-03	2.45-03	3.84-05	7.21-05	4.63-04	4.19-06	9.30-06

6407

WATER EFFLUENT IS REPORTED FOR SUGAR. SUGAR BEET PROCESSING HAS THE FOLLOWING EFFLUENTS (6411,IW15/IW19) ASSUMING SETTLING PONDS- BOD = 6.40 LB/TON, COD = 20.26 LB/TON, DISSOLVED SOLID = 479.23 LB/TON, SS = 44.57 LB/TON, NO3= 1.82 LB/TON AND AMMONIA = 11.14 LB/TON. FROM SUGAR CANE PROCESSING THE EFFLUENT IS REPORTED AS FOLLOWS (6410,1175)- SS = 1750.00 LB /TON, COD = 650 LB/TON, NO3 = 12.00 LB/TON,AND PO4 = 5 LB/TON. TOTAL WATER EFFLUENT OF EACH TYPE IS THE SUM FROM EACH SOURCE WEIGHTED BY PRODUCTION (THIS REPRESENTS 34PC OF TOTAL- SUGAR BEET PROCESSING = 0.11, SUGAR CANE PROCESSING = 0.23)

6408

INCLUDED UNDER THE CLASSIFICATION OF BEVERAGES AND CANNED, CURED AND FROZEN FOOD ARE SIC 208 AND SIC 203.SOURCES OF INFORMATION ON PRODUCTION ARE (0011), (6400) AND WHERE NECESSARY TO TAKE AVERAGE VALUE OF PRODUCT (6402) AND (6409).

6409

THE ONLY AIR EMISSIONS THAT ARE REPORTED FOR PROCESSES ARE IN MAKE ING BEVERAGES (0002,6-6)- 5.00 LB PARTICULATE / TON PRODUCT. OTHER EMISSIONS OCCUR FROM USE OF FUEL FOR HEATING AND STEAM GENERATION. ESSENTIALY ALL FUEL INPUTS ARE USED FOR THIS, THUS 3.13-02 TON OF COAL, 4.04-02 BARREL DISTILLATE, 8.13-02 BBL RESIDUAL AND 1.66-03 MMCF OF NATURAL GAS IS USED PER TON PRODUCT. USING THE FACTORS FROM (0002,1-3/1-9) THE EMISSIONS ARE AS FOLLOWS

PART	SOX	CO	HYDCARB	NOX	ALDEHYD	ORGANIC
2.94-03	1.98-03	3.16-05	4.91-05	3.42-04	2.65-06	5.82-06

TOTAL EMISSION FOR EACH TYPE IS THE SUM OF THE PROCESS AND THE FUEL USE EMISSION

6410

SOLID WASTE IS REPORTED FOR CANNED, DRYED AND FROZEN FRUITS AND VEGETABLES AS FOLLOWS (6417)- TON/1000 TON PROCESSED

VEGETABLES	1037.0
FRUITS	526.0
SPECIALTIES	93.0

TOTAL SOLID WASTE IS THE SUM OF THE ABOVE WEIGHTED BY THEIR RESPECTIVE PC OF PRODUCTION. THESE EQUAL 29PC OF TOTAL PRODUCT (VEGETABLES = 0.10, FRUITS = 0.06, SPECIALTIES = 0.10)

6411

WATER EFFLUENT FOR BEVERAGE AND CANNED, CURED AND FROZEN FOODS IS AS FOLLOWS- TON/TON PRODUCT

WINERY (6412,332) -BOD-= 8.28-05, COD = 3.78-05, SS = 2.90-05
BREWERY (6413) -BOD = 6.24-03, COD = 8.75-03, SS = 2.07-03
CANNERY (6414), (6415), (6416)- BOD = 1.15-02, COD = 1.71-02
PO4 = 3.32-05, NO4 = 1.35-04
SS = 1.18-04, TDS = 1.77-01,

FTN. 6412-6502

BASES = 4.55-05, ALK = 5.51-04 999
ORGANIC = 5.51-04 1099
FROZEN (6414)- BOD = 2.11-01, COD-= 1.92-01, TDS = 2.61-02 1199
TOTAL WATER EFFLUENT IS THE SUM OF EACH SOURCE FOR EACH TYPE 1299
WEIGHTED BY THE RESPECTIVE PC OF PRODUCTION OF EACH SOURCE. 1399
(WINE = 0.06, BREWERY = 0.19, CANNERY = 0.24, FROZEN = 0.063 1499
OF TOTAL PRODUCTION) 1599

6412 199
INCLUDED UNDER THE CLASSIFICATION OF GRAIN MILL AND MISCELLANEOUS 299
FOOD AND KINDRED PRODUCTS ARE SIC 204 AND SIC 209. SOURCES OF 399
INFORMATION ON PRODUCTION ARE (6400), (0011) AND (6402). 499

6413 199
AIR EMISSION FROM PROCESSES ARE REPORTED AS FOLLOWS: 299
ALFALFA DEHYDRATING (0002,6-1) 60.0 LB/TON PARTICULATE 399
COFFEE ROASTER (0002,6-2) 8.7 LB/TON PARTICULATE 499
0.1 LB/TON NOX 599
0.2 LB/TON ALDEHYDES 699
0.9 LB/TON ORGANIC ACID 799
FEED AND GRAIN MILLS 31.6 LB/TON PARTICULATE 899
STARCH MANUFACTURING 8.0 LB/TON PARTICULATE 999
OTHER EMISSION OCCUR FROM FUEL USED FOR STEAM GENERATION AND 1099
HEATING. ESSENTIALLY ALL FUELS INPUT CAN BE CONSIDERED TO BE 1199
USED, THUS FROM FOOTNOTE 6410, 1.02-02 TON OF COAL, 4.45-03 1299
BARREL DISTILLATE, 6.89-03 BARREL RESIDUAL AND 3.27-03 MMCF 1399
NATURAL GAS ARE USED FOR ONE TON OF PRODUCT. USING THE 1499
EMISSION FACTOR FROM (0002,1-3/1-9) THE EMISSIONS FROM THIS 1599
SOURCE IN TONS ARE AS FOLLOWS- 1699

PART	SOX	CO	HYDCARB	NOX	ALDEHYD	ORGANIC
9.62-04	6.47-04	1.03-05	1.17-05	9.76-05	5.25-07	1.15-06

1799 1899
TOTAL EMISSION IS THE SUM OF THE PROCESS EMISSIONS WEIGHTED BY 1999
PC OF TOTAL PRODUCTION OF EACH SOURCE PLUS THE THE EMISSION 2099
FROM FUEL USED FOR STEAM GENERATION AND HEATING 2199

6414 199
THE ONLY WATER EFFLUENT REPORTED IS 2.0 PC OF PROCESSED FEED 299
MATERIAL IS DISSOLVED SOLIDS FOR WET CORN MILLING (6418,322) 399
THIS IS 40.00 LB/TON GRAIN PROCESSED. WET CORN MILLING MAKES 499
UP 2.0 PC OF TOTAL PRODUCTION 599

6415 199
TOTAL DISSOLVED SOLID IS THE SUM OF THE LISTED DISSOLVED SOLIDS 299

6500 199
FUELS AND ELECTRIC ENERGY PURCHASED FOR HEAT AND POWER IN 1967 299
FROM (6110,18). INCLUDES PULPMILLS, PAPERMILLS, PAPERBOARD 399
MILLS, INCLUDING BUILDING PAPER. USED TOTAL MILL PRODUCT 499
TONNAGES IN 1967 & 1971 (0011,634) TO GET DIVISOR. 599

6501 199
FUELS AND ELECTRIC ENERGY PURCHASED FOR HEAT AND POWER IN 1967 299
FROM (6110,18). INCLUDES CONVERTED PRODUCTS AND PAPERBOARD 399
CONTAINERS, BOXES. MULTIPLIER IS THE TONNAGE OF MILL PRODUCT 499
FROM FOOTNOTE 6500 MINUS BUILDING PAPER. THIS ASSUMES ONLY 599
BUILDING PAPER IS NOT FABRICATED AFTER IT IS MADE AND CUT. 699
THIS MULTIPLIER IS THE TONNAGE OF INPUT,RATHER THAN OUTPUT, 799
FOR CONVENIENCE. 899

6502 199
WATER POLLUTANTS FROM (0016). THOUGH DATA IS FOR 1969, COMPARISON 299
WITH 1972 GUIDELINES(6503) AND EXTRAPOLATIONS FROM (6502) 399
SHOWS THAT IT PROBABLY IS MORE ACCURATE FOR 1971. PAPER IND- 499
USTRY POLLUTION RATES HAVE DIMINISHED RAPIDLY IN RECENT 599
YEARS. DATA FROM (0016) IS CLOSE TO THE -B- STANDARDS 699

FTN. 6503

FROM THE 1972 GUIDELINES(6503). EXTRAPOLATIONS FROM (6502), AN EARLIER, DETAILED STUDY, SHOW 1971 EFFLUENTS(POLLUTION) ABOUT 3 TIMES THOSE FROM (6503 AND 0016). THAT EXTRAPOLATION WAS VALID AT THE TIME (6502) WAS DONE. IT ALLOWED FOR THE EMERGENCE OF NEW TECHNOLOGY, ETC. IT WAS USED TO PROJECT THE CORRECT VOLUME OF TOTAL WASTEWATER IN 1972, ABOUT 35.8 THOUSAND GAL PER TON PRODUCTION. (0016,27) SHOWS 2.60E+06 LB BOD PER DAY FROM PLANTS PRODUCING 1.89E+09 GAL/DAY TOTAL DISCHARGE. AT 350 DAY/YEAR AND 5.42E+07 TONS/YEAR, THAT IS 1.33E+06 TONS BOD/YEAR OR 2.46E-02 TON/TON PRODUCT.(0016,29) REPORTS 2.22E+06 LB SUSPENDED SOLIDS PER DAY FROM PLANTS PRODUCING 1.77E+09 GAL/DAY WASTEWATER. THAT IS 1.22E+06 TONS/YEAR, OR 2.25E-02 TON/TON PRODUCT. (0016,28) REPORTS 1.64E+06 LB/DAY COD FROM PLANTS PRODUCING 1.77E+09 GAL/DAY WATER. THAT IS 9.04E+05 TON/YEAR, OR 1.67E-02 TON/TON PRODUCT. DISSOLVED SOLIDS WERE OBTAINED FROM (6502) AND REDUCED BY FACTOR OF 0.4, SINCE BOD AND SUSPENDED SOLIDS DATA FROM (6502) PROJECTIONS WERE 0.45, 0.38 TIMES THAN (0016) DATA, RESPECTIVELY. THE FOLLOWING SHOWS THE USE OF (6502) IN PROJECTING 1971-72 POLLUTION RATES. NOTE THAT ONLY THE RESULT FOR DISSOLVED SOLIDS IS USED. REFERENCE (6502) ASSUMES THE SHARE OF PRODUCT MADE BY KRAFT, SULFITE, BLEACHED, UNBLEACHED IS SAME AS IN 1963, BUT CONSIDERS THE OVERALL SHIFT TO NEWER TECHNOLOGY THROUGH YEARS 1967-1972-1977. ASSUMES THAT POLLUTION FROM INTEGRATED PAPER MILLS REPRESENTS POLLUTANTS PER TON PRODUCT FOR ENTIRE MILL INDUSTRY. IT GIVES POLLUTANTS FOR OLDER,PRESENT-1967, AND NEWER TECHNOLOGY, AND ESTIMATES PERCENT OF PLANTS AT EACH LEVEL IN 1972--- 11PC-OLDER,58PC-PRESENT,31PC-NEWER. MEDIAN PLANT SIZES ARE---

OLDER	260 TONS/DAY
PRESENT	550 TONS/DAY
NEWER	850 TONS/DAY

WEIGHTING BY PLANT SIZES GIVES SHARES OF 1972 PRODUCTION, BY TONNAGE--- OLDER-5PC, PRESENT-52PC,NEWER-43PC. FINAL TONS POLLUTANT/TONS PRODUCT WERE COMPUTED BY WEIGHTING WASTELOADS FROM FOLLOWING TABLE (6502,25) BY 1972 PRODUCTION SHARES ABOVE---

	-WASTELOADS-LBS/TON PRODUCT-			
	SUS. SOLIDS	DIS. SOLIDS	TOTAL SOLIDS	BOD
OLDER	190	810	1000	200
PRESENT	120	550	670	135
NEWER	90	260	350	80

NOT SHOWN ON TABLE IS 35.75 THOUSAND GAL.TOTAL WASTEWATER EFFLUENT PER TON PAPERMILL PRODUCTION, FOR 1972, CALCULATED IN SAME WAY. FINALLY, AFTER COMPARING WITH DATA FROM (0016) AND (6503), THE CORRECTION FACTOR OF 0.4 WAS APPLIED. NO COD WAS INCLUDED IN (6502).

6503

AIR POLLUTANTS COME FROM THREE MAIN SOURCES-- PULP PROCESSING, BARK BURNING, AND BURNING OTHER FUELS FOR STEAM GENERATION. PAPERBOARD DRYING PRODUCES NEGLIGIBLY SMALL PARTICULATE EMISSIONS(0002,10-4).

PULP PROCESSING--FOR EACH TON OF WOODPULP USED IN MILLS IN 1971, 54.15/43.61=1.24 TON OF PAPER AND BOARD WERE MADE, FROM (0011,633). REF.(0002,10-3) GIVES FACTORS PER TON PULP MADE. WE ASSUME THE AVERAGE RECOVERY BOILER IS EQUIPPED WITH A VENTURI SCRUBBER.HALF OF ALL LIME KILNS HAVE A SCRUBBER AND HALF ARE UNCONTROLLED. EMISSIONS FROM FLUIDIZED BED

FTN. 6504

CALCINATORS ARE NEGLIGIBLE (FEW INSTALLATIONS). FROM (0002), WE INCLUDE FACTORS FROM BLOW TANK ACCUMULATOR, WASHERS AND SCREENS, MULTIPLE-EFFECT EVAPORATORS, RECOVERY BOILERS, SMELT DISSOLVING TANK, LIME KILNS, AND TURPENTINE CONDENSORS. WE ASSUME ALL THESE ARE USED FOR EACH TON OF PULP MADE.

BARK BURNING--FROM (6501,8-12), 175 TONS OF BARK ARE BURNED PER YEAR FOR EACH TON OF PULP MADE PER DAY IN THAT YEAR. FROM (0011,633), IN 1971, 43.6 MILLION TONS OF PULP WERE MADE. AT 350 DAYS/YEAR, THAT IS 124 THOUSAND TONS PULP PER DAY, AND 21.7 MILLION TONS WOOD BARK PER YEAR. REF. (0002, 1-11) GIVES EMISSIONS FOR BURNING WOOD AND BARK IN BOILERS, BY TON WEIGHT.

STEAM GENERATION--ALL FOSSIL FUELS PURCHASED ARE ASSUMED USED TO MAKE STEAM (AND ELECTRICITY). COMPUTING EMISSIONS FROM (0002, 1-3/1-9) FOR EACH FUEL GIVES EMISSIONS PER TON OF MILL END PRODUCT, PAPER AND PAPERBOARD, CORRECTED FROM PULP PRODUCTION BASIS REPORTED---

AIR POLLUTANTS FROM BURNING FUELS (EXCEPT WOOD)
IN TONS POLLUTANT PER TON PAPER
(NEGATIVE EXPONENTS FOLLOW EACH NUMBER)

	COAL	RESID	DISTIL	GAS	TOTAL
PARTICULATES	9.09-03	2.61-04	6.32-05	6.27-05	9.48-03
CO	2.80-04	2.27-06	8.41-07	1.39-06	2.84-04
HC	1.40-04	3.41-05	1.26-05	1.39-04	3.26-04
NOX	2.10-03	6.81-04	2.53-04	6.08-04	3.64-03
SOX	1.06-02	3.13-03	1.36-04	2.09-06	1.39-02
ALDEHYDES-(AND OTHER)	6.98-07	1.14-05	8.42-06	3.48-05	5.52-05

TO GET THESE NUMBERS, WE ASSUME 50 PERCENT COLLECTION EFFICIENT FLY-ASH (PARTICULATE) CONTROLS ON COAL BOILERS. ASSUME COAL IS 10 PERCENT ASH, 2 PERCENT SULFUR, FROM (5510). ASSUME RESIDUAL FUEL OIL IS 1.73 PERCENT SULFUR (NO.5 GRADE), AND DISTILLATE FUEL OIL IS 0.224 PERCENT SULFUR (NO.2 GRADE), FROM (5109). BTU CONVERSIONS FROM (0005).

TOTAL POLLUTANTS-- IN USING FACTORS FROM (0002), WE ASSUME THAT THE KRAFT PROCESS (OF PULPING) REPRESENTS THE INDUSTRY. ABOUT 80-85 PERCENT OF PULP IS KRAFT PROCESSED. THE TOTALS SHOWN ON THE TABLE ARE BROKEN DOWN BELOW---

AIR POLLUTANTS FROM ALL MILL SOURCES
IN TONS POLLUTANT PER TON PAPER
(NEGATIVE EXPONENTS FOLLOW EACH NUMBER)

	PULP PROCESS	BARK	OTHER FUEL	TOTAL
PARTICULATES	2.98-02	6.00-03	9.48-03	4.53-02
CO	2.82-02	4.00-04	2.84-04	2.89-02
HC	---	4.00-04	3.26-04	7.26-04
NOX	---	2.00-03	3.64-03	5.64-03
SOX	2.02-03	6.00-04	1.39-02	1.65-02
OTHER	7.78-03	1.00-04	5.52-05	7.94-03

6504

ASSUME ALL PURCHASED FUELS USED FOR HEATING DESIGNATED LARGE COMMERCIAL IN (0002). BTU CONVERSIONS FROM (0005). NOMINAL 10 PERCENT ASH, 2 PERCENT SULFUR COAL, FROM (5510). ASSUME RESIDUAL FUEL OIL IS 1.73 PERCENT SULFUR AND DISTILLATE IS 0.224 PERCENT SULFUR, FROM (5109). A LISTING BY FUEL FOLLOWS--

AIR POLLUTANTS FROM PAPER PRODUCTS
MANUFACTURING
IN TONS POLLUTANT PER TON PAPER INPUT
(NEGATIVE EXPONENTS FOLLOW EACH NUMBER)

FTN. 6505-6601

	COAL	RESID	DISTIL	GAS	TOTAL
PARTIC	1.32-04	1.63-05	8.89-06	5.69-06	1.63-04
CO	4.07-06	1.43-07	1.19-07	5.99-06	1.03-05
HC	2.03-06	2.12-06	1.77-06	2.40-06	8.32-06
NOX	3.04-05	4.26-05	3.56-05	2.99-05	1.39-04
SOX	1.54-04	1.95-06	1.92-05	1.80-07	1.75-04
OTHER	1.01-08	7.08-07	1.19-06	3.30-06	5.21-06

6505

(0016,28) SHOWS 1.644E+06 LB/DAY COD FROM 1.77E+09 GAL/DAY WATER DISCHARGED IN 1969. FOOTNOTE 6502 GIVES 3.575E+04 GAL WATER PER TON MILL PRODUCTION (5.42E+07 TONS IN 1971). MULTIPLYING GIVES 0.904E+06 TONS COD IN 1971. BUT BOD AND SUSPENDED SOLIDS DATA DERIVED FROM MORE DETAILED REF. (6502) ARE 2.2 &2.6 TIMES SURVEY DATA FROM (0016), RESPECTIVELY. WE MULTIPLY BY 2.5 TO GET 2.26E+06 TONS COD, 1971, FROM ALL MILLS.

6506

(0016,30) GIVES A RANGE OF PH VALUES OF DISCHARGED WASTEWATERS FROM 3.4 TO 10.0. (6502,37) GIVES A RANGE OF 3.5 TO 11 OR 12 FOR MAIN MILL WASTEWATERS. (6503,4) LIMITS PH BY REGULATION TO BETWEEN 6.0 AND 8.5.

6600

ENERGY USED IN IRON & STEEL MAKING IS BASED ON DATA REPORTED BY AISI FOR 1972 (6600,53,54,59). ALL VALUES OF ENERGY USE ARE BTU/TON RAW STEEL PRODUCED. THE AGGREGATE ENERGY FOR MAKING STEEL INCLUDES IRON VIA THE BLAST FURNACE BUT DOES NOT INCLUDE IRON ORE AND LIMESTONE MINING AND SHIPMENT. THIS IS CONSISTENT WITH THE DEFINITION OF INDUSTRIES UNDER SIC 33.

A BREAKDOWN OF FUELS USED FOR IRON & STEEL IS AS FOLLOWS--

COAL(OTHER THAN FOR COKE)	4.36E06	TONS
COKE(CONSUMED)	54.8E06	TONS
FUEL OIL	1.313E09	GAL
TAR&PITCH	232.E06	GAL
LPG	14.96E06	GAL
NATURAL GAS	771.9E09	CUBIC FT
PURCHASED ELECTRICITY	39.36E09	KWH

RAW STEEL PRODUCED IN 1972 WAS 133.24E06 TONS(6600,8)

CONVERSION FROM BULK FUEL USE TO BTU USING (0005,38) AND THE FOLLOWING FACTORS-- TAR & PITCH AT 6E06 BTU/BBL OR 0.143 BTU/GAL, LPG AT 95,500 BTU/GAL

FOR PURPOSES OF REPORTING,'FUEL OIL' FIGURE OBTAINED FROM AISI HAS BEEN PROPORTIONED INTO DISTILLATE & RESID USING DATA IN (0041) FOR 1967. THIS SHOWED FUEL OIL TO BE 39PC DSTL AND 61PC RESID BY VOLUME. TAR & PITCH HAS BEEN REPORTED AS AS PART OF RESID, LPG AS PART OF NATURAL GAS AND PURCHASED ELECTRICITY AT 3 TIMES BTU EQUIVALENCE.

NOTE ENERGY IS ON A COKE INPUT SINCE CONVERSION OF COAL TO COKE IS HANDLED SEPARATELY IN THE SUPPLY TABLES FOR COAL. THE AGGREGATE ENERGY USE BASED ON A COAL INPUT (TO INCLUDE COKE PRODUCTION) IS 26.3E06 BTU/TON OF STEEL FOR 1972. COKE OVEN & BLAST FURNACE GASES ARE NOT INCLUDED IN STEEL ENERGY INPUTS SINCE THEY ARE ACCOUNTED FOR IN INPUTS TO COKE OVEN AND BLAST FURNACE PROCESSES. TOTAL ENERGY USE DERIVED FROM ROW 43 DATA IS REPRESENTATIVE OF SIC 3312

6601

ENERGY USE FOR IRON & STEEL CASTINGS(SIC 332) IS BASED ON ON 1967 DATA. THE MULTIPLIER IS FOR 1969, OBTAINED FROM(0007) BULK

FTN. 6602-6604

ENERGY USE IS SHOWN BELOW. ALL VALUES EXCEPT COKE FROM (0041,22,23)

COAL (OTHER THAN FOR COKE)	419.6E03	TONS
COKE	3485. E03	TONS
DISTILLATE	916. E03	BBL
RESIDUAL	377.5E03	BBL
NATURAL GAS	55.6E09	CU FT
PURCHASED ELECT	581.7E07	KWH

ESTIMATED COKE USE FROM (0001,413). THIS ESTIMATE DIFFERS GREATLY FROM (0041) AND IS A POTENTIAL SOURCE OF ERROR. FERROUS CASTINGS IN 1967 BREAK DOWN AS FOLLOWS (0007,103)

GREY IRON	14.33E06	TONS
MALLEABLE IRON	1.04E06	TONS
STEEL	1.86E06	TONS
TOTAL	17.23E06	TONS

ENERGY VALUE FOR EACH FUEL DERIVED USING HEAT VALUES FROM (0005,38) AND THE TOTAL CASTINGS PRODUCED OF 17.23E06 TONS/YR THE MEASURE IS TON OF AVERAGE CASTING

6602

ENERGY USE IN BTU/TON OF PRIMARY ALUMINUM PRODUCED IS DERIVED FROM FUEL USE REPORTED IN (0041,22,23) AND ELECTRODE CARBON REPORTED IN (6601) BULK FUEL USE ESTIMATED FOR 1967 FOLLOWS (0041)

COAL	565.2 E03	TONS
PETROLEUM COKE	1.95E06	TONS (FOR 1968)
DISTILLATE	36.2 E03	BBL
RESIDUAL	106.7 E03	BBL
NATURAL GAS	13.08E10	CU FT
PURCHASED ELECT.	41.96E09	KWH

PRIMARY ALUMINUM PRODUCED IN 1967 WAS 3.269E06 T (0001,151) CONVERSION OF FUEL USE TO BTU USING HEAT VALUES FROM (0005,38) TONS OF PETROL. COKE/TON ALUMINUM = 0.60 USING ABOVE DATA PETROL COKE CONVERTED FROM VOL TO WEIGHT MEASURE USING 401. LB/BBL (0010,588),GIVING 30.E06 BTU/TON PETROL COKE AND CONTRIBUTING 10 PC OF THE TOTAL ALUM. ENERGY REQUIREMENT. OF 195.5E06 BTU/TON. FOR COMPARISON,ALCOA REPORTS AN ENERGY VALUE FOR PRIMARY ALUM OF 216.E06 BTU/TON (6602,58). THE MULTIPLIER IS FROM (0025,167)

6603

ENERGY USE IN BTU/TON PRIMARY COPPER PRODUCED IS DERIVED FROM FUEL USE REPORTED IN (0041,22,23) BULK FUEL USED IN 1967 PRIMARY COPPER PRODUCTION IS AS FOLLOWS

COAL	159.7 E03	TONS
COKE	12.8 E03	TONS
DISTILLATE	120.9 E03	BBL
RESID	1454. E03	BBL
NATURAL GAS	26.31E09	CU FT
PURCHASED ELECT	859.8 E06	KWH

PRIMARY COPPER PRODUCED IN 1967 = 1.133E06TONS (0001,452). ENERGY VALUES IN THE TABLE USE THE ABOVE DATA AND HEAT VALUES FROM (0005,38). THE MULTIPLIER IS PRIMARY PRODUCTION FOR 1970 FROM (0025,468). FOR COMPARISON,SRI (0007,111) REPORTS THE ENERGY VALUE FOR PRIMARY COPPER TO BE 40E06 BTU/TON.

6604

ENERGY USE IN BTU/TON OF PRIMARY ZINC HAS BEEN OBTAINED FROM CENSUS DATA (0041,22,23) BUT WITH A MODIFICATION OF COKE USE TO REFLECT REDUCING REQUIREMENTS FOR DISTILLED ZINC. THE 1967 SLAB ZINC PRODUCTION IS AS FOLLOWS (0001,1156)

ELECTROLYTIC PRIMARY	371,267 TONS	-	39.6 PC
DISTILLED PRIMARY	567,563 TONS	-	60.4 PC

TOTAL 938,830 TONS

ELECTROLYTIC ZINC USES ALUMINUM ELECTRODES. DISTILLED ZINC USES 0.5 TO 0.8 TONS OF COAL OR COKE PER TON ZINC OUTPUT. (6601,810).THE COAL OR COKE IS A REDUCING AGENT. COKE USE HAS BEEN COMPUTED USING 0.5 TONS/TON DISTILLED ZINC (0.302 TONS /TON TOTAL PRIMARY ZINC). BULK FUEL USE IS AS FOLLOWS FOR 1967-----

COAL	678.6 E03	TON
COKE	284. E03	TON
DISTILLATE	8.3 E03	BBL
NATURAL GAS	27.35E09	CU FT
PURCHASED ELECT.	1493. E06	KWH

THE 1970 MULTIPLIER FOR PRIMARY ZINC TONNAGE IS FROM (0025,1175) PRIMARY ZINC CORRESPONDS TO SIC 3333.

6605

PARTICULATE EMISSIONS ARE THE AGGREGATE OF IRON & STEEL MAKING BASED ON THE OUTPUT OF A TON OF RAW STEEL. THE RATIO,TONS PIG IRON/TON STEEL , IS 0.617 (0025,594). EMISSIONS DURING THE SINTERING PROCESS OF IRON MAKING ARE EXPRESSED IN TERMS OF TONS OF SINTER IN THE SOURCE MATL (0002) THIS IS CONVERTED TO IRON OUTPUT USING 0.507 TONS SINTER/TON PIG IRON USING SINTER PRODUCTION DATA FROM (0025,589). EMISSIONS FROM COKING ARE INCLUDED IN COAL SUPPLY. UNCONTROLLED EMISSIONS, CURRENT LEVEL OF CONTROL AND CURRENT INDUSTRY AVERAGE EMISSIONS FOLLOW

PROCESS	UNCONTROLLED LB/TON(0002,7-9)	CURRENT LEVEL CONTROL(6603)	CURRENT EMISSION LB/TON
BLAST FURNACE	150	99 PC	1.5/ IRON
SINTERING	42	95	2.1/ SINTER
OPEN HEARTH			
OXYGEN LANCE	22	90	2.2/LANCED STL
NO OXYGEN LANCE	12	45	6.6/UNLAN. STL
BOF	46	92	3.7/BOF STEEL
ELECTRIC ARC			
OXYGEN LANCE	11	90	1.1/LANCED STL
NO OXYGEN LANCE	7	45	3.9/UNLAN STL
SCARFING	20	25	15. /SCARF STL

NOTE THAT THE CURRENT EMISSION LEVEL DERIVES FROM AN ESTIMATED LEVEL OF PARTICULATE CONTROL THAT REPRESENTS THE AVERAGE OF THE IRON AND STEEL INDUSTRY IN 1973. THE CONTROL LEVELS ARE LESS THAN THEORETICAL EFFICIENCIES. SPECIFIC LEVELS AT ANY ONE SITE ARE HIGHLY DEPENDENT ON LOCAL AIR QUALITY LEVELS.

DATA AGGREGATION FOR STEEL PRODUCTION PROCESSES USES THE FOLLOWING BREAKDOWN (0025,605)

OPEN HEARTH	36.6 PC	OF STEEL PRODUCED
BOP	48.1 PC	
ELECTRIC ARC	15.3 PC	

OPEN HEARTH AND ELECTRIC ARC PRODUCTION ARE ASSUMED TO HAVE A 50/50 MIX BETWEEN LANCED AND NO-LANCED STEEL

6606

NOX EMISSIONS FOR SEVERAL PARTS OF IRON AND STEEL MAKING ARE REPORTED IN (6604) THE VALUES AVAILABLE ARE AS FOLLOWS

	LBS NOX		
BLAST FURNACE	0.444	LBS/TON IRON	CALC.FROM (6604,7-34)
IRON SINTERING	1.04	LBS/TON SINTER	(6604,7-36)
OPEN HEARTH	245.	LBS/TON STEEL	(6604,7-34)
BOP	0.36-1.0	LBS/TON STEEL	(6604,7-35)

THE EMISSIONS ARE RELATIVELY UNCONTROLLED. AGGREGATION INTO TONS/TON RAW STEEL USES THE CONVERSION FACTORS AND

FTN. 6607-6630

STEEL PRODUCTION BY PROCESS MIX GIVEN IN FOOTNOTE 6605. BOP EMISSION TAKEN AT 0.7 LBS NOX/TON STEEL .

6607

SOX IS GENERATED FOR SINTER OPERATION AT RATE OF 3 LBS SO2 /TON SINTER (0002,7-9) CONVERSION TO TONS/TON OF STEEL USING FOOTNOTE 6605 FACTORS. OTHER SOX SOURCES NOT AVAILABLE BUT PROBABLY SMALL.

6608

CO EMISSIONS ARE FROM IRON SINTERING AND BOP/ELECTRIC ARC STEEL FURNACES. CO GENERATED IN THE BLAST FURNACE IS USED AS FUEL AND SLIPS ARE NOT CONSIDERED TO OCCUR. EMISSION FACTORS FROM (0002,7-9) ARE AS FOLLOWS--

SINTER 44 LBS CO/TON SINTER = 22.3 LB/TON PIG IRON
BOP STEEL 1.5 LB/TON BOP STEEL = 0.7 LB/ TON ALL STEEL
ELECT ARC 18 LB/TON LANCED E-A STEEL = 1.4 LB /TON ALL STL
18 LB/TON NO-LANCED E-A STEEL =1.4 LB/TON ALL STL

CO FROM THE BOP FURNACE IS AN AVERAGE VALUE . ELECTRIC ARC PRODUCTION ASSUMES 50/50 MIX BETWEEN LANCED AND NO-LANCED SINTER AND IRON STEEL EQUIVALENTS FROM FOOTNOTE 6605.

6609

THE PRIMARY SOLID BY-PRODUCT IS THE SLAG PRODUCED IN THE BLAST FURNACE PROCESS. THE SLAG IS READILY SALABLE AS A GENERAL RULE FOR BALLAST,CEMENT AGGREGATE AND LAND FILL (6601,305) AND IS NOT CONSIDERED A SOLID WASTE. SOLIDS GENERATED BY PARTICULATE CONTROL HAVE NOT BEEN ASSESSED.

6610

AVERAGE WATER CONSUMPTION FOR THE STEEL INDUSTRY IS 29000 GAL/TON USING 1968 DATA (6605,7-20). BECAUSE OF MANY OUTFALLS FOR EACH STEEL MILL, AVERAGE TEMP RISE IS NOT AVAILABLE.

6611

EFFLUENT CHARACTERISTICS VARY GREATLY FROM ONE LOCATION TO ANOTHER, ALLOWABLE DISCHARGE DEPENDS UPON THE RECEIVING WATER CHARACTERISTICS. THE WATER POLLUTANTS ARE DERIVED FROM TREATMENT LEVEL B INTERIM EFFLUENT GUIDELINES ISSUED BY THE EPA FOR INDUSTRY SIC 3312 (6606). PROCESSES WHICH PRODUCE EFFLUENTS ARE NOT NECESSARILY RELATED TO ENERGY USE AND HENCE THE AGGREGATE EFFLUENT FROM SIC3312 HAS BEEN DERIVED FROM ONLY THE FOLLOWING OPERATIONS GIVEN IN IN(6606)

IRON MANUFACTURING-SUSPENDED SOLIDS,NH3,CYANIDE,PHENOL
STEEL MANUFACTURING-SUSPENDED SOLIDS
HOT FORMING -SUSPENDED SOLIDS,OIL&GREASE

EFFLUENTS FOR IRON MANUFACTURE HAVE BEEN EXPRESSED AS TONS PER TON OF STEEL USING 0.617 TONS IRON/TON STEEL (0025,594) ALL STEEL IS ASSUMED TO BE HOT FORMED. AFTER CONVERSION TO TONS/TON RAW STEEL AND AGGREGATION, THE TOTAL EFFLUENTS ARE AS FOLLOWS--

SUSPENDED SOLIDS	1.21E-03	TONS/TON
AMMONIA	6.20E-05	
CYANIDE	6.20E-06	
PHENOL	3.08E-06	
OIL & GREASE	4.50E-04	

6630

AIR EMISSION FROM PRIMARY ALUMINUM PRODUCTION IS REPORTED BY (0042,7.1-5/7.1-6). SINCE A WIDE RANGE AND AMOUNT OF CONTROL ARE USED IN THE INDUSTRY, THE MINIMUM AMOUNT OF CONTROL IS USED. THE EMISSONS ARE AS FOLLOWS, IN TON/TON PRIMARY ALUMINUM

	PART	FLOURIDE	PART	FLOURIDE
BAUXITE GRINDING				
SPRAY TOWER	4.07-03	--		--
CALCINING OF AL(OH)3				

SPRAY TOWER	6.00-02	--	--	FTN. 6631-6634
ANODE BAKING FURNACE				1099
DRY ELECTROSTATIC PREC.	5.65-04	4.65-04	0.00-00	1199
PREBAKED REDUCTION CELL (PB)				1299
MULTIPLE CYCLONE	8.95-02	1.24-02	2.24-03	1399
HORIZONTAL-STUD (HSS)				1499
SODERBERG CELL				1599
SPRAY TOWER	1.40-02	1.06-03	2.22-03	1699
VERTICLE-STUD (VSS)				1799
SODERBERG CELL				1899
SPRAY TOWER	9.80-03	1.52-04	1.32-03	1999
TOTAL	1.26-01	2.12-02	2.12-03	2099

THE TOTAL INCLUDES THE AVERAGE CELL EMISSIONS. THE AVERAGE 2199
CELL EMISSION IS CALCULATED BY WEIGHTING BY PC OF PRODUCTION. 2299
(PB = 61.9 PC, HSS = 25.5 PC, VSS = 12.6 PC) (0042,7.1-2/3) 2399

2499

6631 199

EMISSION OF NOX, SOX, HYDROCARBONS AND CO ARE SMALL OR NEGLIGIBLE 299
FROM THE PROCESS. THE FUELS INPUT INTO THE INDUSTRY ARE 399
ESSENTIALY ALL USED FOR ELECTRICITY PRODUCTION (0041,SR4-22/23) 499

6632 199

UNCONTROLLED EMISSIONS OF PARTICULATE AND SOX ARE REPORTED FOR 299
COPPER SMELTERS (0042,7.3-2). ELECTROSTATIC PRECIPITATORS AND 399
CYCLONES ARE THE MOST COMMON SOURCES OF CONTROL (0042,7.3-1) 499
BASED UPON THIS AND THE EFFICIENCY OF THE PRECIPITATOR = 99.7 599
AND CYCLONE = 90.0,THE EMISSIONS ARE AS FOLLOWS, TON/TON OF 699
PRIMARY COPPER - 799

	PART	SOX	
ROASTING	2.70-04	1.20-02	899
SMELTING (REVEBRERATORY FURNACE)	1.20-04	6.40-02	999
CONVERTING	3.60-04	1.74-01	1099
REFINING	6.00-05	--	1199
TOTAL	8.10-04	2.50-01	1299

6633 199

AIR EMISSIONS FROM ZINC SMELTING ARE GIVEN IN (0042,7.7-01). ALL 299
ZINC SMELTING PROCESSES START BY ROASTING AND SINTERING OF 399
ZINC OXIDES. AIR EMISSONS DIFFER ONLY IN THE PROCESSES USED 499
FOR THE EXTRACTION OF ZINC METAL--HORIZONTAL RETORTS, VERTICAL 599
RETORTS, ELECTROLYTIC PROCESS. FROM (0028,1192,1193) THE PC 699
BREAKDOWN IN PROCESSES ARE 41.0 PC ELECTROLYTIC, 35.0 PC 799
VERTICAL RETORT AND 26.0 PC HORIZONTAL RETORT. FROM THE ABOVE, 899
THE EMISSIONS IN TON/TON METAL ARE AS FOLLOWS. (ASSUMING 999
ELECTROSTATIC PRECIPITATORS USED FOR PARTICULATE CONTROL AND 1099
50 PC CONTROL IN SULFUR EMISSION) 1199

	PARTICULATES	SULFUR OXIDES	
ROASTING	4.80-03	2.20-02	1299
SINTERING	3.60-03	--	1399
HORIZONTAL RETORT	1.66-04	--	1499
VERTICAL RETORT	1.40-03	--	1599
ELECTROLYTIC PROCESS	4.92-05	--	1699
TOTAL	1.00-02	2.20-02	1799

1899

6634 199

AIR EMISSIONS FOR IRON AND STEEL CASTINGS CONSIST PRIMARILY OF 299
PARTICULATES, CO AND NOX (0042,7.10-1,7.13-2). ASSUMING THAT 399
MOST OF THE IRON CASTING PRODUCTION IS BY CUPOLA AND PRODUCT- 499
ION OF STEEL CASTINGS IS DISTRIBUTED EVENLY BETWEEN ELECTRIC 599
ARC, OPEN-HEARTH AND ELECTRIC INDUCTION, THE EMISSIONS ARE AS 699
FOLLOWS,(IN TONS)- IRON CASTING (ASSUMING WET CAP AND AFTER 799
BURNER)= 4.00-03 TON PART. AND 4.50-03 TON CO , STEEL CASTING- 899
ELECTRIC ARC = 1.08-04 TON PART AND 3.30-05 TON NOX, OPEN 999
HEARTH = 8.65-05 TON PART. AND 1.65-06 TON NOX, ELECTRIC 1099
INDUCTION = 8.25-07 TON PART. (ASSUMING ELECTROSTATIC 1199
PRECIPITATOR). TOTAL EMISSONS ARE THE SUM OF THE EMISSIONS OF 1299

FTN. 6635-6702
IRON CASTINGS AND STEEL CASTINGS WEIGHTED BY THEIR RESPECTIVE 1399
PC OF PRODUCTION (IRON CASTING = 89.2 AND STEEL CASTING = 1499
1C.8) 1599

6635 199
HYDROCARBON, SOX, ALDEHYDES AND METALLICS ARE EMITED BUT 299
ARE HIGHLY VARIABLE (0042,7.10-1,7.13-1). HYDROCARBONS EXIST 399
FROM THE COKE USED IN THE CHARGE TO CUPOLA IN IRON CASTINGS 499
AND FROM OIL COATINGS ON SCRAP USED IN BOTH PROCESSES. SOX AND 599
ALDEHYDES ARE DEPENDENT UPON THE COKE CHARGED AND METALLICS 699
FROM METAL CHARGED. 799

6636 199
MAXIMUM ALLOWABLE EFFLUENT LEVEL FOR PRIMARY ALUMINUM MANUFACTURE 299
IS 10.0 LB/TON FLUORIDE, 10.0 LB/TON SS AND 5.0 LB/TON OIL AND 399
GREASE (6630,8). FROM (0016,E99) BOD FOR 4 PLANTS WAS 554.0 LB 499
/DAY, COD FOR 2 PLANTS WAS 23558.0 LB/DAY FROM (0016,E100). 599
AVERAGE PRODUCTION PER PLANT IS EQUAL TO 1.54+05 TON/YR (0001, 699
151,164). ASSUMING A 360 DAY OPERATING YEAR,PRODUCTION PER 799
PLANT = 428.0 TON PER DAY, THUS BOD = 3.24-01 LB/TON AND COD = 899
2.75+01 LB/TON OF PRIMARY ALUMINUM. 999

6637 199
COD EFFLUENT IS REPORTED FOR ONE PRIMARY COPPER PRODUCER AS 1335.0 299
LB/DAY (0016,100) AND SS IS REPORTED AS 10680.0 LB (0016,101) 399
FROM (6631,BB) AVERAGE PRODUCTION IS 1.10+05 TON PER YEAR. 499
ASSUMING 360 PRODUCING DAYS PER YEAR, PRODUCTION PER PLANT = 599
306.0 TON PER DAY, THUS COD = 2.18-03 TON AND SS = 1.74-02 TON 699
PER TON PRIMARY COPPER 799

6638 199
EFFLUENT FROM IRON FOUNDRIES CONSIST OF 1917.0 LB BOD FOR 5 PLANTS 299
(0016,99), 7135.0 LB COD FOR 3 PLANTS AND 9946.0 LB SS FOR 7 399
PLANTS. AVERAGE PRODUCTION PER PLANT IS 1.35+04 TON PER YEAR. 499
(6632,3-57) AND (0007,103). ASSUMING 260 PRODUCING DAYS PER 599
YEAR, PRODUCTION PER DAY PER PLANT = 52.0 TON. BASED UPON THIS 699
BOD = 3.69-03 TON, COD = 2.29-02 TON, SS = 1.37-02 TON. ALL 799
IMPACTS ARE PER AVERAGE TON OF CASTINGS. 899

6701 199
USE RATES ARE BASED ON 1967 FUEL, PRODUCTION FIGURES FROM (6701). 299
INCLUDES PASS CARS,TRUCKS, TRUCK TRACTORS, CHASSIS, AND BUSES 399
AS NEW UNITS (ALL SIC 3711). INCLUDES MOTOR VEHICLE PARTS 499
AND ACCESSORIES AS PARTS (SIC 3714). TOTAL UNITS IN 1967 FROM 599
(6701,16). TONS OF PARTS BASED ON AVERAGE VALUE PER LB OF 699
35 CENTS FOR WHEELS,SHOCKS,MUFFLERS, AND ENGINES, FROM 799
(7004,IV-31) AND (6701,18).NOTE THAT MOST PARTS ARE SHIPPED 899
TO AUTO MANUFACTURING PLANTS. CARE MUST BE TAKEN IN SEPARATING 999
IMPACTS. 1971 MULTIPLIER FOUND BY MULTIPLYING 1967 109
PRODUCTION BY 1971 SALES PASSENGER CARS/1967 SALES=8585/7437 119
=1.15. SALES RECORDS FROM (0011) AND (0018).1967 PRODUCTION 129
OF PASS CARS WAS 7.32E+06 UNITS (6701,16). 1967 VALUE OF PARTS 139
AND ACCESSORIES WAS 1.1735E+10 DOLLARS (6701,18). TOTAL 149
ESTIMATED WEIGHT OF PARTS IN 1967 IS THEN 3.36E+10 LBS, OR 159
1.68E+07 TONS. 169

6702 19
AIR POLLUTANTS ARE FROM (0002). ASSUME FOSSIL FUELS BURNED IN 29
GENERAL INDUSTRIAL BOILERS. ASSUME 50 PERCENT FLY-ASH CONTROL, 39
10 PERCENT ASH-2 PERCENT SULFUR BITUMINOUS COAL, 0.224 PERCENT 49
SULFUR DISTILLATE, 1.73 PERCENT SULFUR RESIDUAL OIL (5510), 59
(5109). NOT INCLUDED ARE ANY EXHAUSTED POLLUTANTS FROM 69
PAINTING, ETC., WHICH ARE PRESUMED SMALL AND NOT DIRECTLY 79
RESULTANT FROM ENERGY USE. 89

6703

POLLUTANTS FROM BODY AND FINAL ASSEMBLY OPERATIONS. TAKEN LARGELY FROM -B- SCHEDULE IN (6702,7), AND MAY BE MORE REPRESENTATIVE OF 1972 THAN 1971. TOTALS FROM (6702,7/8) MULTIPLIED BY 1.16 TO INCLUDE TRUCKS, BUSES (WHICH ARE HEAVIER). CORRECTION FACTOR FROM (6703,6). OIL, GREASE ENTERED AS ORGANICS. TOTAL CHROMIUM, PHOSPHATE (NOT ENTERED) ARE CHROMIUM--2.81E-06 TONS/UNIT PHOSPHATE--2.81E-05 TON/UNIT NO COD FACTORS IN (6702). TOTAL UNCONTROLLED COD,BOD GIVEN IN (6703,5). ALSO SAYS COD,BOD REMOVAL EFFICIENCIES 80 TO 95 PERCENT. COMPARING 1.61E-03 TON/UNIT BOD (6703,5) WITH 1.10E-04 TON/UNIT FROM (6702,7/8) SHOWS A 93 PERCENT REMOVAL EFFICIENCY. USING THIS EFFICIENCY FOR COD YIELDS 3.53E-04 TON/UNIT.

6704

POLLUTANTS FROM PARTS, ACCESSORIES, TAKEN LARGELY FROM -B- SCHEDULE IN (6702,7/8).THOUGH MOST PARTS ARE MADE IN PARTS PLANTS, ABOUT 30 PERCENT OF GAS ENGINES, FOR INSTANCE, WERE MADE IN PLANTS CLASSIFIED AS BODY OR FINAL ASSEMBLY, IN 1967 (6701,16/18). WE DO NOT ACCOUNT FOR POLLUTION DUE TO THOSE PARTS MADE IN VEHICLE ASSEMBLY PLANTS. ONE COULD ASSUME THE 30 PERCENT FIGURE FOR ENGINES WAS APPLICABLE FOR ALL PARTS, AND ADD 30/70 = 43 PERCENT OF THESE WATER POLLUTANTS(FOR PARTS) TO NEW VEHICLE POLLUTANTS BY RE-NORMALIZING TO A UNIT VEHICLE MULTIPLIER. WE INCLUDE EMISSIONS FROM CASTING OPERATIONS, ENGINE MANUFACTURE, ELECTROPLATING, FRAME MANUFACTURE, AND PARTS STAMPING. IN GENERAL, THE UNITS GIVEN IN (6702,7/8) WERE TRANSFORMED INTO POLLUTANTS PER TON PARTS PRODUCED BY ESTIMATING THE WEIGHT OF AN AVERAGE PRODUCT (FRAME, SQUARE FOOT OF STAMPED METAL) AND ESTIMATING THE NO. OF PARTS MADE IN 1971(I.E., ABOUT 8 MILLION ENGINES, MADE IN PARTS PLANTS). WHERE DATA ON THE ACTUAL NO. OF A MAJOR PART MADE WAS NOT FOUND, AN ESTIMATE OF 8 MILLION WAS USED (I.E., FOR EACH SET OF STAMPINGS). THE FOLLOWING ASSUMPTIONS WERE USED FOR UNITS TRANSFORMATIONS.

THE AVERAGE ENGINE WEIGHS 550 LBS (7004,IV).
THE AVERAGE VEHICLE HAS 550 LBS CAST IRON (7004,IV).
ABOUT 8.16 MILLION ENGINES WERE MADE IN 1971(6701,18).
THE AVERAGE CAR HAS 3000 LBS STAMPED METALS(7004,IV-26).
STAMPED FRAMES ARE .118 IN. STEEL(6705,50).
STAMPED HOODS ARE .036 IN. STEEL(6706,30).
AVERAGE STAMPING IS ABOUT .075 IN.
AUTOMOTIVE STEEL IS AROUND 0.25 LB/CI (6708,87).
EFFLUENTS REPORTED PER AUTO PART CAN BE SCALED TO INCLUDE TRUCKS, BUSES BY MULTIPLYING BY 1.16 (6703,6).
EACH FRAME WEIGHS 1000 LBS. ALL VEHICLES HAVE ONE. ABOUT 8 MILLION WERE MADE IN PARTS PLANTS, 1971. IN 1971
VEGA BUMPERS WERE .09 IN. STEEL (6707,55).ASSUME AVERAGE IS .1 IN. STEEL FOR PLATED PARTS.
ASSUME 15 SF PLATED STEEL PER VEHICLE. ABOUT 8 MILLION SETS PLATED PARTS WERE MADE IN PARTS PLANTS, 1971.

FOLLOWING WATER POLLUTANTS ENTERED AS OTHER IN THE TABLE. UNITS ARE TONS POLLUTANT PER TON 1971 TOTAL PARTS PRODUCTION.

COPPER	1.02E-06	CHROMIUM	2.95E-06	PHENOLS	5.23E-06
NICKEL	8.32E-07	IRON	3.92E-06	PHOSPHATES	2.64E-05
CYANIDE	2.10E-08	ZINC	5.89E-06		

OILS, GREASE ENTERED AS ORGANICS.

NOTE- ELECTRICAL ENERGY CONSUMPTION GIVEN IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE EFFICIENCY OF POWER PLANT ELECTRICITY PRODUCTION.

X. TRANSPORTATION END USE

A. Introduction

Environmental impacts and energy efficiency within the transportation sector are shown in Table 30. As with most other end uses, air emissions are the most readily identifiable impact that are directly related to energy consumption. Transportation has been broken into four major categories; freight, passenger, feedstock and military and government. Energy use rate and environmental impacts associated with each specific use under these four categories are generally appropriate for the 1970 to 1973 time period. For the automobile, the emission controls are at the level for the average automobile in use during 1973. Where possible, the measure of use is ton-mile or passenger-mile. For some uses, however, the only use measure available is gallons of fuel.

As an exercise in data validity and usefulness, some of the information in Table 30 has been carried a step further in order to arrive at total Btu's consumed and total air pollutants emitted.

Multiplying Column 29 x Column 28 yields the total Btu consumed for specific use. Summing these products yields the Btu's consumed for each category:

Category	Btu's	% of Total
Freight	48.05×10^{14}	28.0
Passenger	115.23×10^{14}	67.1
Feedstock	1.53×10^{14}	0.9
Military and Government	7.01×10^{14}	4.1
Total	171.8×10^{14} Btu	

The year associated with the total of 171.8×10^{14} Btu's is somewhere between 1970 and 1971. Bureau of Mines data, which includes military fuel, gives a total of 170.8×10^{14} Btu for 1971 and 164.9×10^{14} Btu for 1970. The agreement between Bureau of Mines data and Table 30 aggregation is good considering that each involves a different approach to arriving at total energy use.

A similar technique has been used on transportation air impact data to determine total tons of air pollutants in the transportation sector. (Column 19 is multiplied by Column 29.)

Category	Tons of Air Pollutants	% of Total
Freight	219.0×10^5	20.6
Passenger	841.0×10^5	78.9
Feedstock	0	0
Military and Government	5.4×10^5	0.5
Total	1.07×10^8 Tons	

This total value can be compared with the aggregate air emissions for U.S. transportation derived from the "Nationwide Inventory of Air Pollutant Emissions, 1968" prepared by USDHEW in August 1970. Summing HEW data for CO, particulates, SO_x, HC and NO_x yields 0.89×10^8 tons (for 1968).

B. Impact Data Table and Footnotes

UNCONTROLLED

END USE SECTOR

TRANSPORTATION

ROW	MNE-MON.	END USE	1 ACIDS	2 BASES	3 DISSOLVED SOLIDS PO_4	4 DISSOLVED SOLIDS NO_3	5 DISSOLVED SOLIDS OTHER	6 DISSOLVED SOLIDS TOTAL (DS)	7 SUSPENDED SOLIDS	8 ORGANICS	9 TOTAL COL'S 6,7,8	10 BOD	11 COD	12 THERMAL (BTU/MEAS.)	13 PARTIC-ULATES	14 NO_x	15 SO_x
			WATER POLLUTANTS (TONS/MEASURE, EX COL. 12)												AIR POL		
1		PRESENT															
2		BARGE - DISTL	0000	0000	0000		2 0007	1 0007	0000	0000	0000	0000	0000	1 0007	1 31-07 3 7027	4 70-07 3 7027	6 73-08 3 7017
3		SHIP PURCHASE TRADE RESID	0000	0000	0000	0000	2 0007	1 0007	0000	0000	0000	0000	0000	1 0007	1 88-07 3 7028	1 03-07 3 7028	1 88-07 3 7030
4		TRUCK-DISTL	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	1 20-07 3 7018	2 40-07 3 7018	2 30-07 3 7018
5		TRUCK GASOLINE	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	2 25-07 3 7018	4 35-08 3 7018	1 35-07 3 7018
6		RAIL-DISTL	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	4 50-08 3 7026	1 05-07 3 7020	1 69-07 3 7026
7		AIRPLANE-DOMESTIC-JET	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	7 50-07 4 7021	2 85-07 4 7021	1 40-07 4 7021
8		AIRPLANE-INTERNAT - JET	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	7 50-07 4 7021	3 45-07 4 7021	1 40-07 4 7032
9																	
10		PASSENGER															
11		AUTO-INTERCITY - GASO	0000	0000	0000	0000	0000	0000	0000	2 0007	2 0007	0000	0000	0000	3 05-07 3 7018	1 46-08 3 7018	6 29-08 3 7018
12		AUTO-URBAN-GASO	0000	0000	0000	0000	0000	0000	0000	2 0007	2 0007	0000	0000	0000	1 95-07 3 7018	1 46-08 3 7018	1 18-07 3 7018
13		BUS-INTERCITY DISTL	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	4 65-08 3 7023	1 30-06 3 7023	1 06-07 3 7023
14		BUS-INTERCITY-GASO	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	1 09-08 3 7022	1 85-07 3 7022	8 35-08 3 7022
15		BUS-URBAN DISTL	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	1 05-07 3 7023	2 06-08 3 7023	2 10-07 3 7023
16		BUS-URBAN-GASO	0000	0000	0000	0000	0000	0000	0000	2 0007	1 0007	0000	0000	0000	2 15-08 3 7022	3 26-07 3 7022	2 30-08 3 7022
17		AIR-CIVIL-DOMESTIC-JET	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	7 42-07 3 7031	1 65-07 3 7031	4 20-08 3 7031
18		AIR-CIVIL-INTERNAT-JET	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	7 53-08 3 7034	4 40-08 3 7034	1 67-08 3 7034
19		MOTORCYCLE - GASO	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	2 50-07 2 7030	6 30-08 2 7030	4 41-08 3 7030
20		[illegible] MECHANISM-GASO	0000	0000	0000	0000	1 02-01 4 7030	0000	0000	0000	0000	0000	0000	1 0007	0000	1 53-01 2 7030	1 40-01 3 7030
21		RAIL-URBAN RAPID TRANSIT ELECT	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
22		RAIL-INTERCITY ELECT	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
23		RAIL-INTERCITY DISTL	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
24		GENL AVIATION-PISTON-GASO	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	2 [illegible]-07 3 7024	8 65-07 3 7024	5 12-07 3 7024
25		GENL AVIATION-TURBINE-JET	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	1 06-06 3 7030	1 80-04 3 7030	5 00-08 3 7034
26																	
27																	
28		FEEDSTOCK LUBRICANT	0000	0000	0000	0000	0000	0000	0000	7 00-05 3 7017	7 00-05 3	0000	0000	0000	1 0007	1 0007	1 0007
29		MILITARY & GOVMT															
30		AIRCRAFT-PISTON-GASO	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	5 55-06 4 7041	4 45-07 4 7041	1 45-07 4 7041
31		AIRCRAFT-TURBINE-JET	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	3 30-06 4 7042	1 14-06 4 7042	6 50-07 4 7042
32		GROUND VEHICLES-GASO	0000	0000	0000	0000	0000	0000	0000	1 0007	1 0007	0000	0000	0000	4 19-08 3 7043	7 93-25 4 7043	2 49-08 3 7043
33		SHIPS-DISTL	0000	0000	0000	0000	2 0007	2 0007	0000	0000	0000	0000	0000	1 0007	5 55-05 3 7027	1 75-04 3 7027	2 49-03 3 7027
34		SHIPS-RESID	0000	0000	0000	0000	2 0007	2 0007	0000	0000	0000	0000	0000	1 0007	1 17-05 3 7029	2 35-05 3 7030	7 35-05 3 7030
35																	
36																	
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OTE: ELECTRICAL ENERGY CONSUMPTION IN BTU'S IS DERIVED BY TAKING THE BTU EQUIVALENT OF KWH (3413) AND MULTIPLYING BY 3 TO REFLECT THE FOSSIL FUEL EQUIVALENT OF ELECTRICITY.

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
AIR POLLUTANTS (TONS/MEASURE)									OCCUPATIONAL HEALTH									
...STIC+ ...LATES	NO_x	SO_x	HYDRO-CARBONS	CO	ALDEHYDES ETC.	TOTAL	SOLIDS (TONS/MEAS.)	LAND (ACRES)	DEATHS MEAS	INJURIES MEAS	MAN-DAYS LOST/MEAS	POTENTIAL LARGE SCALE DISASTER	FUEL	MEASURE	ENERGY (BTU/MEAS.)	MULTIPLIER	MULTIPLIER YEAR	ROW
...-07 3 7021	4.70-07 3 7027	6.73-08 3 7027	2.18-08 3 7027	1.01-07 3 7027	0000	9.30-07 4												1
...-08 3 7026	1.63-07 3 7000	1.06-07 3 7026	1.08-06 2 7000	1.06-07 3 7026	0000	8.10-07 4	7044	0000	0000	0000	0000	0000	DISTILLATE	TON-MILE	3.70+02 2 7001	5.70+11 2	1972	2
...-07 3 7016	3.40-07 3 7016	2.50-07 3 7016	3.40-08 3 7019	2.00-08 3 7019	3.30-08 3 7018	7.30-08 4	7044	7000	0000	0000	0000	0000	RESIDUAL	TON-MILE	3.00+02 2 7002	1.00+12 3	1972	3
...-08 3 7026	1.00-07 3 7020	1.00-07 3 7021	1.30-07 3 7020	1.52-07 3 7020	2.80-08 3 7020	1.70-07 4	7044	7020	0000	0000	0000	0000	DISTILLATE	TON-MILE	3.62+02 2 7004	3.13+11 1	1971	4
...-07 4 7021	3.06-07 4 7021	1.40-07 4 7021	1.40-08 4 7021	1.00-08 4 7021	5.82-08 4 7021	3.03-06 4	7044	0000	0000	0000	0000	0000	GASOLINE	TON-MILE	6.00+02 2 7005	2.00+11 2	1970	5
...-07 4 7033	3.00-07 4 7033	1.50-07 4 7033	1.00-08 4 7033	1.15-08 4 7033	5.62-08 4 7033	5.03-06 4	7044	0000	0000	0000	0000	0000	DISTILLATE	TON-MILE	6.00+02 2 7013	7.00+11 2	1970	6
							7044	0000	0000	0000	0000	0000	JET	TON-MILE	4.20+04 2 7014	3.00+08 2	1970	7
									0000	0000	0000	0000	JET	TON-MILE	4.20+04 2 7015	6.10+08 3	1970	8
																		9
...-07 3 7016	1.40-06 3 7016	6.20-09 3 7016	1.13-06 3 7016	2.25-09 3 7016	1.60-07 3 7016	2.75-05 4												10
...-07 3 7016	1.40-06 3 7016	1.30-07 3 7016	6.70-07 3 7016	4.00-05 3 7016	3.21-07 3 7016	4.40-05 4	7044	7020	0000	0000	0000	0000	GASOLINE	PASS-MILE	2.52+01 2 7003	6.00+11 1	1970	11
...-08 3 7023	1.10-06 3 7023	1.00-07 3 7023	1.30-07 3 7023	8.45-07 3 7023	2.21-08 3 7023	2.54-06 4	7044	7020	0000	0000	0000	0000	GASOLINE	PASS-MILE	6.72+02 2 7006	1.00+12 1	1970	12
...-08 3 7023	2.53-07 3 7023	6.20-08 3 7023	3.30-07 3 7023	2.00-06 3 7023	1.70-06 3 7023	2.70-06 4	7044	7020	0000	0000	0000	0000	DISTILLATE	PASS-MILE	1.07+02 2 7005	2.50+10 2	1971	13
...-07 3 7023	2.50-06 3 7023	2.10-07 3 7023	2.40-07 3 7023	1.81-06 3 7023	6.75-08 3 7023	5.05-06 4	7044	7020	0000	0000	0000	0000	GASOLINE	PASS-MILE	7.50+02 2 7005	6.51+10 2	1971	14
...-08 3 7032	3.24-07 3 7032	1.30-08 3 7032	5.55-07 3 7032	6.65-08 3 7042	3.30-08 3 7032	1.60-06 4	7044	7020	0000	0000	0000	0000	DISTILLATE	PASS-MILE	2.30+03 2 7005	1.66+10 2	1971	15
...-07 3 7032	1.60-07 3 7032	6.20-08 3 7032	5.50-07 3 7032	2.30-07 3 7032	1.05-08 3 7032	8.60-07 4	7044	0000	0000	0000	0000	0000	GASOLINE	PASS-MILE	1.66+03 2 7005	1.61+10 2	1971	16
...-08 3 7034	4.80-08 3 7034	1.67-08 3 7034	8.10-08 3 7034	2.26-08 3 7034	4.70-08 3 7034	1.60-07 4	7044	0000	0000	0000	0000	0000	JET	PASS-MILE	8.32+03 2 7011	1.10+11 1	1970	17
...-07 2 7020	5.21-06 2 7020	4.41-08 3 7020	8.50-08 2 7020	3.80-05 2 7018	6.20-06 2 7020	4.89-05 3	7044	0000	0000	0000	0000	0000	JET	PASS-MILE	5.50+03 2 7012	4.00+10 2	1970	18
0000	1.53-07 3 7035	1.40-07 3 7035	2.50-05 3 7035	1.55-05 3 7035	0000	1.02-04 3	7044	0000	0000	0000	0000	0000	GASOLINE	PASS-MILE	1.52+03 2 7025	1.02+11 3	1968	19
0000	0000	0000	0000	0000	0000		7044	0000	0000	0000	0000	0000	GASOLINE	PASS-MILE	[illegible] 2 7003	2.50+10 [illegible]	1968	20
0000	0000	0000	0000	0000	0000		7016	0000	0000	0000	0000	0000	ELECTRICITY	PASS-MILE	3.30+02 2 7007	7.75+08 2	1970	21
...-07 3 7024	6.65-07 3 7024	5.10-07 3 7024	4.45-07 3 7024	6.20-07 3 7024	8.75-08 3 7024	2.42-06 3	7044	0000	0000	0000	0000	0000	ELECTRICITY	PASS-MILE	2.30+02 2 7004	6.01+08 2	1970	22
...-08 2 7030	1.00-06 3 7030	1.00-08 3 7030	2.66-04 3 7030	6.00-03 3 7030	5.00-05 3 7030	6.45-03 4	7044	0000	0000	0000	0000	0000	DISTILLATE	PASS-MILE	1.00-05 2 7010	6.10+08 2	1968	23
0000	2.60-06 3 7030	6.45-08 3 7040	2.72-04 3 7030	9.50-06 3 7030	0000	1.33-03 4	7044	0000	0000	0000	0000	0000	GASOLINE	HOUR	2.75+06 2 7017	2.60+07 2	1970	24
							7044	0000	0000	0000	0000	0000	JET	HOUR	1.31+07 3 7017	1.50+06 3	1970	25
																		26
1 0000	1 0000	1 0000	2 0000	1 0000	1 0000	3	0000	0000	0000	0000	0000	0000	LUBRICANT	GALS.	1.46+07 3 7008	1.00+08 2	1968	27
																		28
...-08 4 7061	4.60-07 4 7061	1.60-10 4 7061	4.10-08 4 7061	3.30-06 4 7061	2.30-07 4 7061	3.00-03 4												29
...-08 4 7042	1.10-08 4 7042	4.50-07 4 7042	5.00-08 4 7042	3.50-06 4 7042	2.30-07 4 7042	1.57-05 4	7044	0000	0000	0000	0000	0000	GASOLINE	GALS	1.25+05 1 7029	4.10+08 2	1972	30
...-08 3 7043	7.90-08 4 7043	1.60-08 3 7043	1.35-06 4 7043	6.60-01 4 7043	6.80-08 4 7043	1.08-03 4	7044	0000	0000	0000	0000	0000	JET	GALS	1.32+05 1 7029	6.10+08 2	1972	31
...-06 3 7027	1.75-06 3 7027	2.40-05 3 7027	1.10-05 3 7027	7.10-05 3 7027	0000	1.37-04 4	7044	0000	0000	0000	0000	0000	GASOLINE	GALS	1.25+05 1 7029	3.10+08 2	1972	32
...-08 3 7029	3.30-05 3 7029	3.35-05 3 7029	8.50-06 3 7029	7.60-05 3 7029	0000	2.03-04 4	7044	0000	0000	0000	0000	0000	DISTILLATE	GALS	1.10+05 1 7029	1.70+08 2	1972	33
							7044	0000	0000	0000	0000	0000	RESIDUAL	GALS	1.50+05 1 7029	1.70+08 2	1972	34
																		35
																		36
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TABLE 30. ENVIRONMENTAL IMPACTS AND EFFICIENCY OF TRANSPORTATION ENERGY USE

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FOOTNOTES FOR TABLE 30

7001

DOMESTIC TRAFFIC IS COMPOSED LARGELY OF BARGES PUSHED BY DIESEL POWERED TOWBOATS. ENERGY PER TON MILE IS AN AVERAGE VALUE BASED ON 5.29E11 TON-MILES CONSUMING 0.20E15 BTU FOR THE YEAR 1969 (7001).

7002

THE PORTION OF TON-MILES CONSIDERED IS PROPORTIONAL TO ACTUAL BUNKER REPORTS AND REFLECTS ONLY THE FUEL PURCHASED IN THE U.S. BY BOTH U.S. AND FOREIGN SHIPS CARRYING U.S. FOREIGN TRADE GOODS. DATA ON FOREIGN TRADE SHIPPING FROM (7001). FOR 1972, RESIDUAL FUEL REQUIRED FOR FOREIGN TRADE IS ESTIMATED AT 0.42E15 BTU EQUIVALENT.

7003

RECREATION BOAT DATA FROM USCG (7001), (7002). RECREATION BOATS ARE ASSUMED TO AVERAGE 30 HP, 2 CYCLE WITH 3.6 PM/VEHICLE MILE. TOTAL FUEL USE IS CONSIDERABLY LARGER THAN REPORTED FIGURES FROM TAX REBATE RECORDS AND MARINE USE. EST. 1969 CONSUMPTION IS 1.06E9 GAL FOR 23.0E9 PM.

7004

DATA ARE DERIVED USING 2.2 PASSENGER MILES/VEHICLE MILE FROM REFERENCE 7003 (2.2 HOLDS FOR BOTH URBAN AND RURAL). THE NATIONWIDE AVERAGE VEHICLE MILE/GALLON OF GASOLINE FOR 1970 IS 13.57 (7020,52). TOTAL VEHICLE MILEAGE IS DISTRIBUTED 54.4PC URBAN/45.6PC RURAL FOR 1970 (7020,52). URBAN FUEL ECONOMY IS NOT THE SAME AS FEDERAL DRIVING CYCLE FUEL ECONOMY. BASED ON AVAILABLE DATA (7004, IV-18) AN ESTIMATE OF URBAN FUEL ECONOMY IS 12 MPG. NO ESTIMATES EXIST FOR AVERAGE RURAL ECONOMY BUT THE NUMBER CAN BE CALCULATED USING A TANK MILEAGE APPROACH IN CONJUNCTION WITH AN OVERALL ECONOMY OF 13.57 MPG AND THE URBAN VALUE OF 12.0 MPG. THIS CALCULATION YIELDS 16.1 MPG FOR RURAL MILEAGE. OVERALL AUTOMOBILE BTU/PASS-MILE IS 4190 USING 124,952 BTU/GAL (0005,38). THIS OVERALL NUMBER IS MORE ACCURATE THAN THE RESULTING URBAN/RURAL BREAKDOWN. MULTIPLIERS ARE DERIVED FROM 1,959,857E06 TOTAL NATIONAL PM (0021,20) USING A .544/.456 URBAN/RURAL SPLIT.

7005

BTU PER PASS-MILE DERIVED FROM 1969 DATA USING (7006). TRANSIT, INTERCITY, AND SCHOOL BUS DATA HAVE BEEN COMBINED TO FIT CATEGORIES OF URBAN, RURAL, GASOLINE AND DISTILLATE. PASSENGER MILE MULTIPLIER VALUES FOR THE FOUR CATEGORIES IN 1971 ARE DERIVED USING RATIOS OF PASSENGER MILES TO VEHICLE-MILES AVAILABLE FROM 1969 DATA (7006) AND MULTIPLYING BY 1971 VEHICLE-MILE DATA (7007). BTU/PM FOR GASOLINE POWERED BUSES ARE LOW BECAUSE OF HIGHLY LOADED SCHOOL BUSES. PASS-MILE/VEHICLE-MILE ARE AS FOLLOWS:

URBAN-GASOLINE	19.0
URBAN-DIESEL	15.1
RURAL-GASOLINE	24.3
RURAL-DIESEL	21.0

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7006

AN URBAN/RURAL BREAKDOWN IS NOT KNOWN FOR TRUCKS. GAL/MILE DATA FROM (7006) HAVE BEEN COMBINED INTO THE TWO CATEGORIES OF GASOLINE AND DISTILLATE (DIESEL). IN 1969, TON-MILES FOR GASOLINE POWERED TRUCKS WAS 2.64E11, FOR DIESEL IT WAS 2.81E11. TON-MILES PER VEHICLE-MILE FOR GASOLINE POWERED TRUCKS=1.46, FOR DIESEL EQUALS 10.6. THE MULTIPLIER OF TOTAL TON MILES FOR 1971 OBTAINED FROM (7007) DISAGGREGATED INTO GASOLINE AND DIESEL.

7007

ASSUMING THAT URBAN RAIL TRAFFIC IS ALL ELECTRIC. A VALUE OF 0.33 PURCHASED KWH/PASS-MILE IS REPRESENTATIVE OF THE NYC SUBWAY SYSTEM (7008). THE PASSENGER-MILES OF THE NYC SYSTEM COMPRISE THE MAJORITY OF TOTAL RAPID TRANSIT PASS-MILES. TOTAL PASS-MILES OF 7.75E9 FOR RAPID TRANSIT IS A DERIVED NUMBER FOR 1970 USING 2.561E09 TOTAL KWH CONSUMED (7011,20) DIVIDED BY 0.33 KWH/PASS-MILE. KWH CONSUMPTION FOR SUBWAYS INCLUDES LIGHTING AND CONTROLS. CONVERSION OF PURCHASED KWH TO BTU IS AT INPUT TO POWER PLANT USING 10239 BTU/KWH.

7008

USING HEAT VALUE FROM (0005,38). THE TOTAL GALLONS OF LUBRICANTS TO TRANSPORTATION HAS BEEN TAKEN AS THE SUM OF AUTOMOTIVE AND AVIATION LUBRICANTS REPORTED FOR THE YEAR 1969 (7010).

7009

(7008) REPORTS DATA FOR 3 COMMUTER RR'S WITH THE LIRR (HEAVY AIR CONDIT.) AT 0.281 KWH/PM FOR 1.03E9 PASS-MILES. THE AVG. COMMUTER AND INTERCITY OPERATION IS ESTIMATED TO BE ABOUT 0.23 KWH/PM. TOTAL PM ARE DERIVED FROM A KWH VALUE OF 1.39 E9 IN 1970 (0021,67). ABOVE PURCHASED KWH'S CONVERTED TO BTU USING 10239 BTU/KWH.

7010

THE DIESEL INTERCITY COACH TRAIN IS ESTIMATED TO HAVE AN ENERGY USE OF 47.6 PM/GAL (0027,11). PASSENGER-MILES ATTRIBUTABLE TO DIESEL USE OBTAINED BY SUBTRACTING ELECT. PM OF 6.07E9 FROM TOTAL PM OF 12.2E9 OBTAINED FROM (0009,545). (ALL DATA FOR 1969 TO OBTAIN CONSISTENCY.)

7011

TOTAL DOMESTIC PM FOR 1970 (7009) ARE 109,665E6, SUMMING CERTIFICATED ALL SERVICES AND SUPPLEMENTAL. TOTAL FUEL FOR DOMESTIC OPERATIONS IN 1970 WAS 7.65E9 (EXCLUDING AMNT FOR ALL CARGO CARRIERS) GALS (0010,428). GASOLINE USE IS NEGLIGIBLE. (0012) PROVIDES A BREAKDOWN OF JET FUEL CONSUMPTION IN 1970 BY NAPTHA AND KEROSINE TYPE. THE AVERAGE HEATING VALUE FOR JET FUEL ACCORDING TO AMOUNT USED, IS 133,200 BTU/GAL. FUEL USE FOR CIVIL AVIATION WAS 98.6P JET FUEL IN 1968. IT IS BETTER THAN 99P JET FUEL IN 1972.

7012

INTERNATIONAL PASSENGER-MILES ARE TOTAL REPORTED (0021,16) DIVIDED BY TWO TO REFLECT CONSUMPTION OF FUEL LOADED IN THE U.S. BTU/PM IS DERIVED FROM TOTAL FUEL CONSUMED IN INTERNATIONAL OPERATIONS EXCLUDING ALL-CARGO CARRIERS (0010,428) 2.039E09 GAL. BTU/GAL ARE SAME AS IN FOOTNOTE 7011.

7013

REVENUE TON-MILES FOR 1970 ARE FOR CLASS I RAILROADS. BTU/TON-MILE DERIVED FROM FUEL CONSUMPTION AND TON-MILE DATA REPORTED IN (0021,32 and 67).

7014

FROM (0027,9). DOMESTIC TON MILE MULTIPLIER ALSO FROM (0027,9) AND (0011,566).

7015

INTERNATIONAL TON-MILES ARE TOTAL REPORTED (0021,16) DIVIDED BY TWO TO REFLECT CONSUMPTION OF FUEL IN U.S. BTU/TON-MILE ARE ASSUMED TO BE THE SAME AS FOR DOMESTIC TRANSPORT.

7016

DERIVED FROM DATA REPORTED IN (0002,3-2) WHICH REFLECT THE WHOLE 1973 POPULATION OF GASOLINE-ENGINE-POWERED VEHICLES. AUTOMOBILE EMISSIONS PER PASS-MILE BASED ON 2.2 PM/VEHICLE-MILE. (SEE FOOTNOTE 7004.) EVAPORATION AND CRANKCASE LOSSES FROM OLDER CARS APPORTIONED 50/50 FOR URBAN/RURAL. NOX ASSUMED TO BE EQUAL FOR URBAN AND RURAL. PARTICULATES, SOX, ALDEHYDES, ETC. CALCULATED BY WEIGHTING URBAN/RURAL EMISSION ACCORDING TO GAL/MILE (FROM FOOTNOTE 7004). ON THIS BASIS URBAN LB/PASS-MILE = 1.9 TIMES RURAL LB/PASS-MILE.

7017

THE MEASURE FOR GENERAL AVAIATION IS HOURS OF OPERATING TIME. THE BREAKDOWN OF HOURS BY TYPE OF AIRCRAFT IS-SINGLE ENGINE PISTON 76.4P, MULTI-ENGINE PISTON 16.1P, TURBINE FIXED WING 4.3P, TURBINE AND PISTON ROTOR CRAFT 3.1P (7005). JET FUEL USE WAS 1.7E8 GAL, GASOLINE USE 5.29E8 GAL (7005). JET FUEL CONVERSION FROM FOOTNOTE 7011. GASOLINE CONVERTED AT 124,952 BTU/GAL.

7018

DERIVED FROM (0002,3-2) WHERE DATA ARE FOR WHOLE 1973 POPULATION OF GASOLINE-ENGINE-POWERED VEHICLES. TRUCK EMISSIONS PER TON-MILE CALC. USING 1.46 TON-MILES/VEHICLE-MILE. CO BASED ON 64.5 GM/MILE BY COMBINING URBAN/RURAL DATA FROM (0002). HC BASED ON 7.38 GM/MILE.

7019

DIESEL DATA FROM (0002,3-7) USING CONVERSION FACTORS OF 5.1 MILES PER GAL (7006,11) AND 10.6 TON-MILES/VECHICLE-MILE (FOOTNOTE 7006).

7020

DIESEL LOCOMOTIVE DATA REPORTED AS LB/1000 GAL. (0002,3-7). CONVERSION TO TONS/TON-MILE USING 0.323 LOCOMOTIVE MILES/GAL. AND 598 TON-MILES/LOCOMOTIVE-MILE (CALCULATED FROM (0021) NATIONAL STATISTICS).

7021

AIR EMISSIONS ARE FOR LANDING-TAKEOFF (LTO) CYCLE WHICH INCLUDES TAXI AND IDLE. IT IS ASSUMED THAT FREIGHTERS ARE PREDOMINANTLY LONG RANGE TURBOJETS AND TURBOFANS. BASIC DATA ARE IN LBS EMISSION PER LTO-ENGINE. LTO CYCLE STOPS AT 3500 FT ALTITUDE. AVERAGE FREIGHTER ESTIMATED TO USE 200 GALS JET FUEL PER LTO-ENGINE. (0002,3-9 AND 3-10). CONVERSION TO TONS/TON-MILE ASSUMING LTO'S CONSUME 10P OF TOTAL GAL. USED (7021,11). TOTAL GAL/TON-MILE FROM FOOTNOTE 7014.

7022

BASIC EMISSION DATA FROM (0002,3-2). URBAN PASS-MILES/VEH-MILE= 19.0,RURAL PM/VM=24.3 (SEE FOOTNOTE 7005). ON A VEHICLE-MILE BASIS, NOX ASSUMED EQUALLY DISTRIBUTED BETWEEN URBAN/RURAL. DISTRIBUTION OF PART., SOX, AND ALDY. ON THE BASIS OF GAL/MILE, USING URBAN EQUALS 1.6 RURAL GAL/MILE (7006).

7023

AVERAGE EMISSION DATA FROM (0002,3-7). CONVERSION TO LB/PASS-MILE MADE BY DETERMINING URBAN/RURAL EMISSIONS ON BASIS OF URBAN GAL/MILE = 1.55 RURAL GAL/MILE. URBAN PASS-MILE/VEH-MILE = 15.1, RURAL = 21.0. (SEE FOOTNOTE 7005.)

7024

BASIC EMISSION DATA IN GM/PASS-MILE REPORTED IN (7008,4). ASSUMING 0.331 MILES/GAL AND 175 PASSENGERS/LOCOMOTIVE-MILE.

7025

BASED ON 1.1 PM/VM AND 75 MPG AVG. (7006,11). MULTIPLIER OF 1.02E11 PM FROM (7006,11).

7026

LAND USE IS NOT THE DIRECT RESULT OF ENERGY CONSUMPTION. LAND USE ATTRIBUTABLE TO ROAD VEHICLES IS GIVEN FOR REFERENCE ONLY. IT IS BASED ON A LAND AREA FOR 48 STATES OF 1.90E9 ACRES (0009,5). TOTAL ROAD RIGHT OF WAY LAND USE IS 1.1P (REF.7013) OR 21.0E6 ACRES. IF DISTRIBUTION IS TREATED ON BASIS THAT CAR = TRUCK = BUS, THEN ACRES/VEHICLE-MILE = 1.8E-5 (USING 1970 TOTAL VEHICLE MILES = 1.13E12 FROM REF. 0021).

VEHICLE	ACRES/PASS-MILE	ACRES/TON-MILE
URBAN BUS-GASOLINE	9.32E-7	
RURAL BUS-DIESEL	8.45E-7	
URBAN AUTO-GASOLINE	8.05E-6	
RURAL AUTO-DIESEL	8.05E-6	
TRUCK-GASOLINE		1.21E-5
TRUCK-DIESEL		1.67E-6

PASS-MILE & TON MILES PER VEHICLE MILE FROM FOOTNOTES 7004, 7005,7006.

7027

EMISSIONS DATA IN LBS/1000 LBS FUEL FROM REF. (7014,84) BASED LARGELY ON TESTS OF A GM-6-71 DIESEL ENGINE USING 0.25P SULFUR FUEL. CONVERSION USING 7 LBS/GAL AND 139E3 BTU/GAL.

7028

EMISSION DATA IN LBS/1000 LBS FUEL FOR VESSELS OVER 1000 TONS USING BUNKER C FROM REF. (7014,91). THESE ARE IN TURN DERIVED FROM A 1964 BAY AREA APCD STUDY. CONVERSION USING 7 LBS/GAL AND 150E3 BTU/GAL.

7029

CONSUMPTION DATA ARE PURCHASES FOR CONTINENTAL U.S. USE ACCORDING TO RECORDS MAINTAINED BY THE DOD DEFENSE FUEL SUPPLY CENTER (7015). MULTIPLIER CORRESPONDS TO FISCAL YEAR 1972.

7030

THE CURRENT POPULATION OF MOTORCYCLES IS ABOUT 62P FOUR CYCLE AND 38P TWO CYCLE (7016,21). EMISSIONS ASSUME THIS POPULATION SPLIT AND ARE BASED ON FACTORS FROM (7016,25). SULFUR CONTENT IS .043P W FOR 2-STROKE AND .022P W FOR 4-STROKE. CONVERSION FROM GMS/MILE TO TONS/PASS-MILE USES 1.1 PASS-MILE/VEH-MILE FROM FOOTNOTE 7025.

7031

AIR EMISSIONS ARE FOR LANDING-TAKEOFF (LTO) CYCLE WHICH INCLUDES TAXI AND IDLE. LTO CYCLE STOPS AT 3500 FT ALTITUDE. THE AVERAGE DOMESTIC PASSENGER AIRCRAFT IS ASSUMED TO BE A MEDIUM RANGE TURBOFAN ACCORDING TO THE CLASSIFICATION OF DATA IN (0002,3-9). THE AVERAGE PASSENGER PLANE IS ASSUMED TO USE 170 GALS OF JET FUEL PER ENGINE-LTO CYCLE. (0002,3-10). BASIC EMISSION LBS PER ENGINE-LTO ARE DIVIDED BY GAL PER ENGINE-LTO CYCLE TO GET LBS EMISSION PER GAL USED IN LTO CYCLE. CONVERSION TO EMISSION PER PASS-MILE ASSUMES LTO USES 10P OF TOTAL FUEL (7021,11) WITH TOTAL GALS PER PASS-MILE FROM FOOTNOTE 7011.

7032

HC EMISSION CALCULATED AS PER FOOTNOTE 7031 EXCEPT THAT BASIC EMISSION FACTOR OF 17 LBS/ENGINE-LTO IS SAME AS FOR LONG RANGE TURBOFAN.

7033

FOR INTERNATIONAL OPERATIONS WITH ONE TERMINUS OUTSIDE THE U.S., THE ACTUAL EMISSIONS IN TONS DURING THE LTO WILL BE HALVED. POLLUTANTS ARE SAME AS THE ENTRIES FOR AIRPLANE DOMESTIC FREIGHT. HALVING THE EMISSIONS IS ACCOMPLISHED THROUGH THE TON-MILE MULTIPLIER (SEE FOOTNOTE 7015).

7034

FOR INTERNATIONAL OPERATIONS, THE PASSENGER AIRCRAFT IS TAKEN TO BE AN AVERAGE BETWEEN A JUMBO AND LONG-RANGE TURBOFAN. EMISSIONS ARE CALCULATED AS OUTLINED IN FOOTNOTE 7031. REDUCTION IN EMISSIONS DUE TO ONLY ONE LTO BEING IN U.S. IS ACCOUNTED FOR IN THE PM MULTIPLIER (SEE FOOTNOTE 7012). THE AVERAGE INTERNATIONAL AIRCRAFT IS ASSUMED TO USE 250 GALS JET FUEL PER ENGINE-LTO CYCLE (0002,3-10). CONVERSION USES BTU/PASS-MILE FROM FOOTNOTE 7012.

7035

EMISSIONS ARE BASED ON SRI DATA (7017) FOR FOUR TWO-STROKE WATER-COOLED OUTBOARD MOTORS WHOSE AVERAGE RATED HORSEPOWER IS 25 AND AVERAGE LOAD FACTOR IS 0.37. OUTBOARDS ARE ESTIMATED TO CONSUME ABOUT 90P OF THE 1.1E9 GALS OF FUEL USED FOR RECREATIONAL BOATS (SEE FOOTNOTE 7003). EMISSIONS GIVEN ARE FOR A POPULATION CONSISTING WHOLLY OF OUTBOARDS AND ARE CALCULATED USING GRAM/GALLON EMISSION FACTORS (7017,52) MULTIPLIED BY .046 GAL/PASS-MILE FROM FOOTNOTE 7003. AIR EMISSIONS DO NOT INCLUDE EXHAUST PRODUCTS ORIGINALLY RELEASED INTO THE WATER. SOX BASED ON FUEL SULFUR WEIGHT CONTENT OF .043P.

7036

WATER EMISSIONS MEASURED ARE HC, CO, NOX, AND SOX FOR FOUR OUTBOARDS AND REPORTED IN (7017,52). THE WATER EMISSIONS REPORTED ARE GASES WHICH MAY STAY IN THE WATER OR RISE TO THE SURFACE AND BECOME AN AIR CONTAMINANT. THE TOTAL VALUE REPORTED OF 1.92E-5 TONS/PASS-MILE BREAKS DOWN AS FOLLOWS:

	TONS/PM
HC	1.52E-5
CO	3.90E-6
NOX	2.78E-8
SOX	8.15E-9

7037

A STUDY CONDUCTED FOR THE STATE OF MASS. (7018,3) IN 1969 AND CONFIRMED BY API IS ASSUMED REPRESENTATIVE OF THE NATIONAL PICTURE. THE STUDY INDICATED 0.8P OF USED AUTOMOTIVE OILS TO BE DUMPED IN SEWERS. ABOUT 23P OF DUMPED ON THE GROUND AND 18P HAD AN UNKNOWN FATE. THE REMAINDER WAS REPROCESSED TO FUEL OIL (36.6PC), TAKEN OUT OF STATE (8.1PC) OR CONVERTED TO FARM USE (2.4PC). PART OF THE UNKNOWN FRACTION AND PART OF THE GROUND DUMP UNDOUBTEDLY BECOME WATER POLLUTANTS. IT IS CONSERVATIVELY ASSUMED THAT 2P OF ALL LUBRICANTS USED IN TRANSPORTATION BECOME A POLLUTANT. CONVERSION IS AT 7 LBS/GAL.

7038

AIR EMISSIONS ARE FOR THE LTO CYCLE (SEE ALSO FOOTNOTE 7031). IT IS ESTIMATED THAT 10P OF THE TOTAL FUEL IS CONSUMED DURING THE LTO (7021,11). EMISSIONS PER GAL OF GASOLINE USED IN THE LTO ARE CALC. USING EMISSION FACTORS IN LBS/ENGINE-LTO (0002,3-9) DIVIDED BY GALS/ENGINE USED IN THE LTO (0002,3-10). CONVERSION OF EMISSIONS TO LBS/HR ASSUMES THE LTO USES 10P OF TOTAL FUEL CONSUMED.

7039

EMISSIONS ARE FOR THE LTO CYCLE ASSUMING THAT 10P OF TOTAL FUEL IS CONSUMED DURING THE LTO (7021,11). DATA OBTAINED FROM EPA/ANN ARBOR AS REPORTED IN (7019). FUEL CONSUMPTION FOR THE BUSINESS AIRCRAFT DURING THE LTO IS 175 LBS/ENGINE.

7040

SOX EMISSION IS FOR THE LTO AND IS DETERMINED FROM EPA DATA (0002,3-9,3-10) FOR TURBINE ENGINES GIVING .01 LBS SOX PER GAL CONSUMED IN THE LTO. CONVERSION TO LBS/HR USING THE BTU/MEASURE VALUE OF 1.51E7, 133,200 BTU/GAL AND LTO FUEL USE EQUAL TO 1/10 OF TOTAL FUEL USE (7021,11).

7041

PISTON AIRCRAFT EMISSIONS DETERMINED IN SAME MANNER AS FOR CIVIL AIRCRAFT (FOOTNOTE 7031) AND GENERAL AVIATION (FOOTNOTE 7038). BASIC EPA DATA IN LBS PER LTO-ENGINE FROM (0002,3-9) AND (7021,11). THE AVERAGE MILITARY PISTON AIRCRAFT IS REPRESENTED BY THE TRANSPORT DATA OF THE REFERENCE. GALS PER ENGINE-LTO TAKEN AS 45. (0002,3-10).

7042

MILITARY TURBINE AIRCRAFT EMISSIONS ARE CHARACTERIZED BY USING THE AVERAGE TURBOJET AIRCRAFT DATA IN (0002,3-9). MILITARY CRAFT RANGE FROM SINGLE ENGINE TO EIGHT ENGINE B-52'S. GALLONS CONSUMED PER ENGINE-LTO TAKEN AS ABOUT 220 (0002, 3-10) AND (7021,11).

7043

EMISSIONS FOR MILITARY AND GOVERNMENT GROUND VEHICLES ARE ESTIMATED BY USING EPA DATA FOR THE 1973 POPULATION OF GASOLINE POWERED MOTOR VEHICLES (0002,3-2). CO EMISSION IS AVERAGE OF URBAN AND RURAL.HC EMISSION IS AVERAGE OF URBAN AND RURAL PLUS EVAPORATIVE AND CRANKCASE LOSSES. CONVERSION FROM GRAMS/MILE USING AN AVERAGE OF 12.5 MI/GAL.

7044

SOLID WASTE IS NOT ATTRIBUTABLE TO TRANSPORTATION ENERGY CONSUMPTION EXCEPT FOR THE SECONDARY IMPACTS OF DISCARDED PROPULSION SYSTEMS. THE SOLID WASTE CAUSED BY DISCARDING THE COMPLETE VEHICLE, SHIP ETC. WOULD REPRESENT AN EVEN HIGHER ORDER IMPACT. INFORMATION EXISTS FOR CALCULATING SECONDARY IMPACTS IF DESIRED.

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APPENDIX A

LIST OF ABBREVIATIONS

APPENDIX A

LIST OF ABBREVIATIONS

A	Ash
AC	Acre
A/C	Air Conditioner
AMNT	Amount
AV	Average
BAAPCD	San Francisco Bay Area Air Pollution Control District
BADCT	Best Available Demonstrated Control Technology
BBL	Barrel(s)
BCF	Billion Cubic Feet (Standard)
BOD	Biological Oxygen Demand
BPH	Barrels per Hour
BPSD	Barrels per Stream Day
BPY	Barrels per Year
BTU	British Thermal Unit
BTUH	BTU per Hour
B-T-X	Benzene Toluene Xylene
C	Cents
CO	Carbon Monoxide
CAP	Capacity
CD	Calendar Day
CF	Cubic Feet
CY	Cubic Yard
D	Day
DIST or DSTL	Distillate
DOT	Department of Transportation
DS	Dissolved Solids
DSCF	Dry Standard Cubic Feet
DSCFM	Dry Standard Cubic Feet per Minute
DWT	Deadweight
E	Equivalent
ELECT	Electricity
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
F	Fahrenheit
FCR	Fixed Charge Rate
FF	and following pages . . .
FT	Foot (Feet)
GAL	Gallon
GAS	Natural Gas
GASO	Gasoline
GM	Gram
GPD	Gallons per Day

GPM	Gallons per Minute
GR	Grains
HEW	U.S. Department of Health, Education and Welfare
HP	Horsepower
HR	Hour
IN	Inch
KW	Kilowatt
KWH	Kilowatt Hour (Electrical)
L	Liter
LB	Pound
LIRR	Long Island Railroad
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LT	Long Ton
LTS	Long Ton Sulfur
M	Thousand
MCF	Thousand Cubic Feet (Standard)
MEA	Monoethanolomine
MF	Moisture Free
MG	Milligram
MGD	Million Gallons per Day
MI	Mile(s)
MIBK	Methylisobutyl Ketone
MM	Million
MMCF	Million Cubic Feet (Standard)
MMCFD	Million Cubic Feet per Day
MOL	Mole
MPG	Miles per Gallon
MW	Megawatts
NDO	Nondegradable Organics
NMI	Nautical Miles
NO	Number
ODS	Other Dissolved Solids
OST	Office of Science and Technology
P or PC	Percent
PE	Primary Efficiency
PHS	Public Health Service
PM	Passenger Mile
PPM	Parts per Million
PSIA	Pounds per Square Inch Absolute
PSIG	Pounds per Square Inch Gage
RESID or RFO	Residual fuel oil
ROM	Run of Mine
S	Sulfur
SCF	Standard Cubic Feet
SF	Square Foot (Feet)
SGC	Stack Gas Cleaning
SH	Short
SI	Square Inch(es)

SNG	Synthetic Natural Gas
T	Ton(s)
TDS	Total Dissolved Solids
TM or TMI	Ton Mile
TPD	Tons per Day
TPY	Tons per Year
TS	Total Solids (Dissolved + Suspended)
USDI	U.S. Department of the Interior
VM	Vehicle Mile
W or WT	Weight
WAL	Weak Ammonia Liquor
YR	Year